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Estimating the Potential Impacts of a Nuclear Reactor Accident

Methodology and Case Studies

Prepared by J. V. Cartwright, R. M. Beemiller, E. A. Trott, Jr., J. M. Younger

U.S. Department of Commerce

Prepared for
U.S. Nuclear Regulatory
Commission

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Prepared by
J. V. Cartwright, R. M. Beemiller, E. A. Trott, Jr., J. M. Younger

Regional Economic Analysis Division
Bureau of Economic Analysis
U.S. Department of Commerce
Washington, D.C. 20230

Prepared for
Division of Engineering
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
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Joseph V. Cartwright
Richard M. Beemiller
Edward A. Trott, Jr.
James M. Younger
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Chapter 1

INTRODUCTION

This monograph describes an industrial impact model that can be used to estimate the regional industry-specific impacts of disasters. Special attention is given to the impacts of possible nuclear reactor accidents. The monograph also presents three applications of the model. The impacts estimated in the case studies are based on (1) general information and reactor-specific data, supplied by the U.S. Nuclear Regulatory Commission (NRC), (2) regional economic models derived from the Regional Input-Output Modeling System (RIMS II) developed at the Bureau of Economic Analysis (BEA), and (3) additional methodology developed especially for taking into account the unique characteristics of a nuclear reactor accident with respect to regional industrial activity.

Overview of the Industrial Impact Model

The model is based on patterns of wind-carried radiation (released as a consequence of a hypothetical reactor accident), which causes contamination of productive capacity in a physically affected area for varying lengths of time. For example, while the area immediately surrounding the reactor accident may be contaminated for many years, more distant areas are assumed to be affected for shorter periods. The model estimates the first-year industry-specific losses in employment associated with the decrease in regional industrial output caused by the contamination.

In order to estimate impacts, an economic study area is defined to consist of a physically affected area and a physically unaffected area. The industrial impacts estimated in this monograph are for the study area as a whole, since an accident that causes a decrease in output (for example, agricultural output) in the physically affected area also could affect output (for example, food processing) in the physically unaffected area. Regional economic models for the study area, the physically affected area, and the physically unaffected area are estimated by RIMS II. These models identify industry-specific trading activity between the physically affected and unaffected parts of the study area. In addition to the direct effects experienced in the physically affected area, in the immediate aftermath of an accident the following economic effects could occur in the physically unaffected area:

- demand for output previously exported to the affected area would decrease;
- demand for output by tourists who previously came to the unaffected area from elsewhere in the Nation could decrease;
- imports from industries in the affected area would no longer be available to industries in the unaffected area; this could constrain the output of industries in the unaffected area if alternative sources of supply were not forthcoming either from elsewhere in the Nation or from increased production within the unaffected area.

Over a longer period of time after the accident, the following two compensating effects could occur in the physically unaffected area:

- output could increase if excess capacity previously existed;
- people, who evacuated the physically affected area in the immediate aftermath of the accident, could resume their normal consumption expenditures, even though they are unable to live in the physically affected area.

To conclude this overview of the industrial impact model, it is useful to indicate several general patterns of the effects it estimates. First, for accidents that involve several directly affected counties, the largest impacts often occur in the physically affected area itself, because these counties taken together often have large local interindustry relationships and are highly self-sufficient with respect to the study area as a whole. Therefore, "spillover" effects in the physically unaffected area are small. Impacts (whether large or small) due to tourists avoiding the physically unaffected area are concentrated in the two directly affected industries--hotel and lodging places, eating and drinking establishments, and other retail trade.

Second, when excess capacity in the physically unaffected area is sufficiently large, a large portion of the output lost in the physically affected area can be made up elsewhere in the study area. However, even if output increased in the physically affected area, there might be insufficient demand for that output, if employees who previously worked in the physically affected area either were not compensated for their lost income or remained in "evacuation centers" rather than resuming their normal level of consumption expenditures. The impacts of households not maintaining their normal expenditures are large, especially in the local service-type industries.

Scope of the Study

This monograph is divided into nine chapters. Chapter 2 describes the two types of input-output (I-O) models used in the overall industrial impact model. Supply-constrained I-O models, since they have been used far less frequently than demand-driven I-O models, are discussed at greater length. The focus of this discussion is on the empirical difficulties of the supply-constrained I-O model. Chapter 3 contains a short description of the RIMS II methodology used to derive the I-O relationships for the case studies. Moreover, this description of RIMS II is intended to highlight several techniques used in the overall industrial impact model. Chapter 4 describes the overall model of disasters in terms of industry-specific direct effects in a physically affected area, and industry-specific spillover effects in a physically unaffected area. For a disaster in a hypothetical economy, spillover effects are analyzed in terms of demand-driven and supply-constrained I-O models. As in chapter 2, the empirical difficulties of using supply-constrained models are indicated.

Chapter 5 describes specific assumptions adopted for the three case studies presented in chapters 6, 7, and 8. Chapter 9 summarizes the results of the research, especially in terms of the general pattern of results obtained in the case studies.

Chapter 2

REGIONAL INPUT-OUTPUT MODELS

Regional input-output (I-0) analysis is based on industry-specific relationships, which can be used to estimate the effects on regional industrial output, personal income, and employment of changes in regional demand or regional supply conditions.[1] The central element of a regional I-0 model is a transactions table, as shown in table 2.1. For a hypothetical five-sector economy, table 2.1 shows the interaction of industries in a region with each other and with the final demand and final payments sectors. For example, the total output of the manufacturing industry is $105 million, of which $90 million are sales to the five intermediate purchasing industries and $15 million are sales to the three categories of final demand. Similarly, the total inputs to the manufacturing industries are $105 million, of which $65 million are purchases from the five intermediate industries and $40 million are final payments.

Based on a regional transactions table, two distinct regional I-0 models can be formulated, depending on whether changes in demand conditions or changes in supply conditions are viewed as initiating effects in a regional economy. Most frequently, regional I-0 models have been formulated to show regional economic impacts when changes in demand conditions initiate secondary impacts. For example, a Wyoming I-0 model could be formulated to show the effects of increased demand for Wyoming coal on personal income in the mining and mining-supplying industries in Wyoming. Regional I-0 models formulated to take into account changes in demand conditions are often referred to as "demand-driven"

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1. For references to regional I-0 modeling, see Cartwright, et al. (1981). Giarrantani (1980) and Hoover (1971) focus on the differences between demand-driven and supply-constrained models.

Table 2.1.--Hypothetical Regional Transactions Table

(Millions of dollars)

		Purchasing industry						Final demand				
		Agriculture (1)	Construction (2)	Manufacturing (3)	Trade (4)	Services (5)	Total intermediate sales (local)	Household expenditures	Other final demand	Exports	Total final demand	Total outputs
Selling industry	Agriculture (1)	10	5	5	2	0	22	10	10	28	48	70
	Construction (2)	5	20	15	5	5	50	0	40	0	40	90
	Manufacturing (3)	10	30	30	10	10	90	5	5	5	15	105
	Trade (4)	5	10	10	15	10	50	10	7	5	22	72
	Services (5)	15	5	5	20	5	50	15	5	0	20	70
	Total intermediate purchases (local)	45	70	65	52	30	262	40	67	38	145	407
Final payments	Household earnings	15	15	25	5	15	75	2	1	0	3	78
	Other value added	5	1	3	4	5	18	0	0	0	0	18
	Imports	5	4	12	11	20	52	1	0	0	1	53
	Total final payments	25	20	40	20	40	145	3	1	0	4	149
	Total inputs	70	90	105	72	70	407	43	68	38	149	556

models, because changes in regional economic activity are viewed as being caused by changes in the demand for the output of the economy.

Far less frequently, regional I-O models have been formulated to show regional economic impacts when changes in supply conditions initiate secondary impacts. For example, an Oklahoma I-O model could be formulated to show the effects of a decreased supply of irrigation water on personal income in agriculture and agriculture-purchasing industries in Oklahoma. Regional I-O models formulated to take into account changes in supply conditions are often referred to as "supply-constrained" models, because changes in regional economic activity are viewed as caused by changes in the supply of resources available to the region.

Demand-Driven Regional I-O Models

Demand-driven models are formulated by focusing initially on the rows of the transactions table (table 2.1). Each row shows the sales by the industry named at the left (row industry) to the industries identified across the top (column industries), as well as to the final demand components identified in the right-hand section of the table. Thus, the row sum is the total output or total sales of an industry. This can be expressed algebraically for an n sector model as follows:

$$X_i^r = \sum_j X_{ij}^r + FD_i^r \tag{2.1}$$

where:

X_i^r = total sales (gross output) of industry i in region r

X_{ij}^r = sales of industry i in region r to industry j in region r

FD_i^r = sales of industry i in region r to the final demand sector

For many impact analyses, the intermediate (often called the interindustry) quadrant of the table is the most important. The interindustry dollar flows in table 2.1 may be expressed as regional purchase coefficients, which show the purchases from intermediate industries per dollar of total input. The coefficients are derived by dividing each row dollar value by the total dollar value of inputs for that column, that is,

$$a_{ij}^{r} = \frac{X_{ij}^{r}}{X_{j}^{r}} \qquad (2.2)$$

Table 2.2 shows the regional purchase coefficients table for the hypothetical regional economy shown in table 2.1. The total output of a row industry may now be rewritten as:

$$X_{i}^{r} = \sum_{j} a_{ij}^{r} X_{j}^{r} + FD_{i}^{r} \qquad (2.3)$$

In this form, the I-O model becomes useful for analytical purposes since it depicts the direct effect on the output of all the region's industries when output changes in one industry. For example, from table 2.2, the effects per $1 million of output in the agriculture industry are $70,140 ($1 million times .0714) on the output of the construction industry and $142,900 ($1 million times .1429) on the output of the manufacturing industry.

The primary analytical purpose of demand-driven I-O models is to determine the total effects on gross output in all industries (including not only the direct effects, but also the indirect effects) of industry-specific final demand changes. The indirect effects arise from initially affected industries purchasing their inputs. For example, in order to produce the $142,900 of output (required for $1 million of agriculture output), the manufacturing sector must purchase $6,802 of inputs ($142,900 times .0476) from the agriculture industry and $40,827 of inputs ($142,900 times .2857) from itself.

Table 2.2.--Direct Regional Purchase Coefficients

	(1)	(2)	(3)	(4)	(5)
Agriculture (1)	.1429	.0556	.0476	.0278	0
Construction (2)	.0714	.2222	.1429	.0694	.0714
Manufacturing (3)	.1429	.3333	.2857	.1389	.1429
Trade (4)	.0714	.1111	.0952	.2083	.1429
Services (5)	.2143	.0556	.0476	.2778	.0714

To capture these first, second, and other rounds of effects, a multiplier matrix is derived from the table of regional purchase coefficients. Equation 2.3 can be expressed in matrix notation by the following:

$$X^r = A^r X^r + FD^r \qquad (2.4)$$

or

$$X^r - A^r X^r = FD^r \qquad (2.5)$$

where:

X^r = gross output vector

FD^r = final demand vector

A^r = matrix of regional purchase coefficients

From equation 2.5

$$(I - A^r)\ X^r = FD^r \qquad (2.6)$$

where:

I = identity matrix

Expressing gross output as a function of final demand,

$$X^r = (I - A^r)^{-1}\ FD^r \qquad (2.7)$$

The demand-driven multiplier matrix for the hypothetical economy is depicted in table 2.3. The coefficients in the matrix show the direct and indirect requirements of the row industry per dollar of final demand for the output of the column industry.[2] Thus, the final demand change of $1 million for the output of the agriculture industry would lead to output increases

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[2] Demand-driven I-O multipliers can be formulated with some of the components of final demand treated as endogenous sectors; for a discussion, see Cartwright, et al. (1981), pages 27-28.

Table 2.3.--Direct and Indirect Multipliers Matrix (Demand-Driven)

	(1)	(2)	(3)	(4)	(5)
Agriculture (1)	1.2213	.1597	.1298	.0960	.0469
Construction (2)	.2677	1.5219	.3748	.2854	.2186
Manufacturing (3)	.5057	.8746	1.7080	.5390	.4130
Trade (4)	.2823	.3852	.3118	1.4680	.3035
Services (5)	.4082	.2880	.2331	.5060	1.2128

of $1.2213 million in the agriculture industry (including the original $1 million) and $.2677 million in the construction industry; the sum of the industry-specific output changes would be $2.6852 million.

It is important to recognize that the use of equation 2.7 in an analysis of positive final demand changes assumes that sufficient regional capacity exists so that the estimated increases in output can occur.[3] In other words, the demand-driven I-O model assumes that supply in the region is forthcoming. For example, if demand by the rest of the Nation for Wyoming coal increased, then the positive industrial effects estimated by a Wyoming demand-driven I-O model would be based on the assumptions (1) that each affected industry in Wyoming could expand its output up to the point required to sustain the final demand change, and (2) that the pattern of each industry's expansion can be described by the preimpact regional purchase coefficients matrix (A^r). Alternatively, a major assumption when using equation 2.7 in an analysis of negative final demand changes is that no compensating positive final demand changes occur in response to the availability of additional productive capacity in the economy. For example, if demand by the midwestern States for Wyoming coal decreased, then the negative industrial effects estimated by a Wyoming demand-driven I-O model would be based on the assumption that all other sources of final demand for the output of industries in Wyoming were unchanged from their preimpact levels.

Supply-Constrained Regional I-O Models

Supply-constrained models are formulated by focusing initially on the columns of the transactions table. Each column shows the purchases of that column's industry from the row industries as well as the final payments made.[4] Thus, the column sum is the total input or total purchases of that industry. This can be expressed algebraically for an n sector model as follows:

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[3] For a discussion of the other I-O assumptions, see Cartwright, et al. (1981), especially pages 58-60.

$$X_j^r = \sum_i X_{ij}^r + FP_j^r \tag{2.8}$$

where:

FP_j^r = purchases of industry j in region r from the final payments sector

The interindustry dollar flows in table 2.1 may be expressed as regional sales coefficients, which show the sales to intermediate industries per dollar of total output. The coefficients are derived by dividing each column dollar value in a row by the total dollar value of output for that row. That is,

$$b_{ij}^r = \frac{X_{ij}^r}{X_i^r} \tag{2.9}$$

Table 2.4 shows the regional sales coefficients for the hypothetical regional economy shown in table 2.1. The total inputs of a column industry may now be rewritten as:

$$X_j^r = \sum_i X_i^r b_{ij}^r + FP_j^r \tag{2.10}$$

The primary analytical purpose of supply-constrained I-O models is to determine the direct and indirect effects on output in all industries of industry-specific

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[4] Final payments often are referred to as primary inputs in the supply-constraint literature; for more details, see Hoover (1971), pages 233-238. Giarrantani (1977 and 1980) focuses on critical imports as the primary input that can cause supply constraints. Final payments are also referred to as value added in the economic accounting literature; for more details, see the references in Cartwright, et al. (1981).

Table 2.4.--Direct Regional Sales Coefficients

	(1)	(2)	(3)	(4)	(5)
Agriculture (1)	.1429	.0714	.0714	.0286	0
Construction (2)	.0556	.2222	.1667	.0556	.0556
Manufacturing (3)	.0952	.2857	.2857	.0952	.0952
Trade (4)	.0694	.1389	.1389	.2083	.1389
Services (5)	.2143	.0714	.0714	.2857	.0714

constraints on the level of final payments. In order to estimate these effects, a multiplier matrix can be derived from the regional sales coefficients. Equation 2.10 can be expressed in matrix notation as:

$$X^r = X^r B^r + FP^r \qquad (2.11)$$

or

$$X^r - X^r B^r = FP^r \qquad (2.12)$$

where:

X^r = gross input vector

FP^r = final payments vector

B^r = matrix of regional sales coefficients

From equation 2.12

$$X^r(I - B^r) = FP^r \qquad (2.13)$$

or

$$X^r = FP^r(I - B^r)^{-1} \qquad (2.14)$$

The supply-constrained multipliers matrix for the hypothetical economy is shown in table 2.5. The coefficients in the matrix show the direct and indirect effects on output of the column industry per dollar of final payments of the row industry.[5/] Thus, if final payments in agriculture decreased by $1 million, output would decline by $1.2213 million in agriculture and $.2053 million in construction; the sum of the industry-specific output changes would be $1.7662 million.

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5. Hoover (1971), page 235, discusses the circumstances under which households and other components of final payments should be viewed as endogenous in a supply-constrained multiplier matrix.

Table 2.5.--Direct and Indirect Multipliers Matrix (Supply-Constrained)

	(1)	(2)	(3)	(4)	(5)
Agriculture (1)	1.2213	.2053	.1939	.0988	.0469
Construction (2)	.2082	1.5219	.4373	.2283	.1781
Manufacturing (3)	.3372	.7497	1.7080	.3696	.2753
Trade (4)	.2744	.4815	.4547	1.4680	.2950
Services (5)	.4082	.3703	.3497	.5205	1.2128

As with the demand-driven matrix, it is important to be aware of the major assumptions that are implicit in the use of equation 2.14 to analyze the impact of positive and negative changes in final payments.[6] In an impact analysis of positive changes in final payments, it is assumed that there is sufficient demand for the increased output that results from expanding the productive capacity of the economy. In the case of negative changes in final payments, it is assumed that the constrained output is not compensated for by other establishments either in the region or outside the region. If the construction industry in the above example were able to import the agricultural inputs no longer available within the region, this assumption would not be applicable and, furthermore, construction output would not decrease directly.

Additionally, in the case of negative changes in final payments, supply-constrained multipliers are estimated assuming that intermediate and final demand are constant; therefore, these multipliers show only the effects on output of the decreased availability of inputs. For example, when using a supply-constrained I-O model, a scarcity of irrigating water is viewed as initially constraining payments to labor, capital, and other value-added in agriculture, and subsequently decreasing the availability of agriculture inputs to other regional industries (such as food processing and restaurants). Supply-constrained multipliers can be used to estimate output decreases in these industries. However, the supply-constrained I-O model does not estimate any effects due to the decreased demand for inputs, arising, for example, if agriculture demanded less fertilizer, food processing less packaging, or restaurants less advertising. The supply-constrained I-O model can be viewed as

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6. For a more extensive discussion of the assumptions of supply-constrained I-O models, see Hoover (1971), pages 233-238.

assuming that decreases in local demand for fertilizers, packaging, or advertising due to the water constraint would be compensated for by increases in demand from other sources; in other words, supply creates its own demand.

Earnings and Employment Impacts

The impacts of changes in final demand and final payments have been presented in terms of changes in output. However, often the goal of impact analysis is to estimate regional earnings and employment impacts.[7] Based on output changes estimated by either equation 2.7 or 2.14, the following two equations show how earnings and employment impacts can be calculated.

$$\Delta E_i = \left(\frac{E_i}{X_i}\right) \Delta X_i \qquad (2.15)$$

$$\Delta EMP_i = \left(\frac{EMP_i}{E_i}\right) \Delta E_i \qquad (2.16)$$

where:

E_i = earnings in industry i

EMP_i = employment in industry i

In equation 2.15, an industry-specific ratio of earnings to output (E_i/X_i) is used to translate output changes into earnings changes. Earnings, as presented in table 2.1, are shown as final payments to households. Therefore, the ratio of earnings to output for any industry can be calculated by dividing the household earnings in that industry by the industry's total inputs (which equal its output). This ratio is sometimes referred to as the "household-row coefficient" for the industry. In equation 2.16, an industry-specific ratio of employment to earnings (EMP_i/E_i) is used to translate income changes into employment changes. This two-step, sequential procedure for estimating impacts on employment is used in RIMS II; several other regional I-O models rely on only the industry-specific ratios of employment to output (EMP_i/X_i).

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[7] For a more detailed discussion of earnings and employment impacts and multipliers, see Cartwright, et al. (1981), pages 34-38, Schaffer (1976), pages 56-67, and Di Pasquale and Polenske (1980). As estimated in the case studies presented in this monograph, output, earnings, and employment are defined in chapter 5.

Comments on Supply-Constrained I-O Analysis

The basic concept underlying the supply-constrained model is that economic activity is dependent on the availability of resources. Supply-constrained models have been used most frequently to analyze the effects on output of constraints on imports (one component of final payments). For example, a decrease in availability of imported crude oil would affect petroleum refining directly and have extensive indirect impacts on other industries (for example, petrochemical manufacturing and any industry that used refined petroleum for space heating). Even with a total cutoff of imported crude oil, however, an increase in domestic crude oil production or an increase in the output of substitutes (for example, domestic or imported coal) would lessen the impact. Furthermore, in the case of a supply constraint that represents less than a total cutoff of the availability of a particular input, interindustry reallocation of that input (either through the price mechanism or central planning) would change the regional sales coefficients and the resulting supply-constrained multiplier matrix. For this reason, care should be taken in using supply-constrained matrices.

When analyzing simultaneously the impacts of two or more resource constraints, other difficulties in interpreting the results of supply-constrained matrices may arise. Suppose a region's residential construction industry is affected by a decrease in the availability of both imported lumber and imported floor coverings. Furthermore, suppose that the lumber constraint, by itself, would lead to 100 fewer houses being built, and the floor-covering constraint, by itself, to 50 fewer houses being built. Clearly, the lumber constraint is more binding. Furthermore, since 100 fewer houses would be built, floor coverings would not be needed for 100 houses. Therefore, the floor coverings that would have gone into the additional 50 houses (those not affected by the floor-covering constraint) would be available to other regional industries (for example, nonresidential construction).

Another example of multiple constraints serves to highlight further the difficulties in using supply-constrained matrices. Suppose a major automobile manufacturing firm in a region loses a significant portion of its local supply of automobile doors and external mirrors through a physical disaster that curtails local production. If the automobile manufacturer could not locate other suppliers of doors and mirrors, then eventually fully assembled auto output would decline. That is, at some time after the physical disaster, partially assembled autos would reach the point in the assembly line where doors and mirrors would be attached to the auto body, and either too few doors or too few mirrors would be available. Clearly, the situation would be better if the mirror constraints were more binding, since auto assembly would extend further if more doors were available. In this example, the more binding constraint could result in a smaller impact than the less binding constraint. In fact, one alternative available to the auto manufacturer would be to ship cars without mirrors and require retailers to locate their own supplies of mirrors and install them.[8]

The above three examples indicate some of the major difficulties in using supply-constrained multiplier matrices, which are based on the notion that a decrease in the inputs available to an industry curtails that industry's output. In general, these difficulties arise because (1) inputs to the production process are heterogenous and (2) some inputs are more critical than others.[9] For example, crude oil is a critical input to refined petroleum and to petrochemicals, but is a less critical input to electricity-generating utilities, for which coal and nuclear energy often are readily available substitutes. Despite the difficulties in interpreting a supply-constrained model, information provided by the model may be useful because it indicates potential industry-specific impacts of supply constraints. Rather than referring to the output effects of supply constraints as "output decreases," however, it may be preferable to refer to the estimates as "potential output decreases" or "vulnerabilities." Furthermore, an analysis of the impacts of supply constraints should focus on major output vulnerabilities that can be judged likely to occur rather than on those that are small or easily mitigated. For example, if Florida's citrus crops were destroyed by an early frost,

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8. This would be a case of substitution in which, instead of importing the scarce resource, the good minus the scarce resource is exported to a region where the resource is not scarce. In the previous example, if floor coverings were the more binding constraint, houses could be sold without the conventional floor coverings but with consumers obtaining a price reduction or other allowance as compensation.

9. These difficulties are not present in the interpretation of the demand-driven multiplier matrices, which are based on the notion that a decrease (increase) in demand for the output of an industry curtails (expands) its need for inputs. In demand matrices, there is a heterogenous demand (for example, residential or nonresidential investment) for a homogenous input (for example, lumber).

national output of canned and frozen fruits could be affected seriously; in contrast, restaurants would be unlikely to close if they were unable to sell orange juice. As a practical matter, focusing on the regional sales coefficient matrix rather than its inverse might be advisable, since the larger coefficients in the former matrix indicate major vulnerabilities, while coefficients in the inverse matrix include some interindustry effects that are less likely to occur, given the possibilities of both substitution and simultaneous, but unequally binding, constraints.

Finally, the impacts of final demand changes and supply constraints are not additive. Using equation 2.7, the final demand data in table 2.1, and the demand-driven multipliers in table 2.3, if regional final demand ceased (that is, the final demand change equaled the negative of the initial final demand), then the gross output changes would equal the negative of the initial industry-specific gross output, and total gross output would equal zero. Similarily, using equation 2.4, the final payments data in table 2.1, and the supply-constrained multipliers in table 2.5, if regional payments ceased (that is, the final payments change equaled the negative of the initial final payments), then the gross output changes would equal the negative of the initial industry-specific gross output, and total gross output would equal zero. Therefore, regional output can go to zero due to a total collapse of either final demand or final payments. If both collapses occurred simultaneously[10], the output could go only to zero; clearly, the economy could not lose twice its former output. Furthermore, in the impact analyses of situations representing less than a total collapse of final demand or payments, the output decreases associated with negative final demand changes would serve to lessen the effects of supply constraints. For example, if final demand for steel decreased and if, at the same time, energy inputs became scarcer, then the energy that steel previously demanded would lessen the effects of the energy scarcity.

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[10] Giarrantani (1977) shows how supply constraints can constrain final demand. However, he does not discuss the case of simultaneous demand decreases and supply constraints. Economies often are affected simultaneously, but separately, by a demand decrease (for example, agricultural exports) and supply constraints (for example, imported crude oil).

Chapter 3

RIMS II

Overview

Many types of public-sector and private-sector decisions require an evaluation of probable regional effects. For example, Federal requirements for environmental impact statements and the urban impact of Federal policies necessitate regional impact analyses. A growing concern, therefore, about the effects of public and private decisions has created a demand for regional economic impact models. As a result of this demand, economic impact models have been developed for many States and regions. These models vary considerably in terms of structure, reliability, sectoral and geographical detail, flexibility in application, and cost of development and use. In general, the models that provide reliable and industrially detailed secondary impact estimates are expensive to construct, while the less costly models that can be used in numerous small-area studies often provide inaccurate estimates.

In response to the growing need for improved techniques for regional impact analysis, the Regional Economic Analysis Division (READ) of BEA developed the Regional Industrial Multiplier System (RIMS) in the mid-1970's. RIMS was designed to estimate input-output-type multipliers for use in estimating the secondary regional impacts of public and private economic development policies. RIMS was capable of estimating multipliers for any region composed of one or more contiguous counties and for any of the 478 industrial sectors in the 1967 BEA national input-output (I-O) table. A significant improvement over the more summary measures often used in regional impact analysis, RIMS was capable of providing reliable multiplier estimates without the high cost of gathering survey data.

The Regional Input-Output Modeling System (RIMS II) is a refinement of RIMS.[1] The basic differences between RIMS II and RIMS are the use of a more recent national I-O table, the use of more detailed and more current data for regionalizing the national I-O table, and greater flexibility in the derivation of regional impact estimates through the use of a matrix inversion technique that provides industrially disaggregated impacts.

RIMS II multipliers are intended to show the total regional effects on industrial output and personal earnings for any county or group of counties in the United States and for any of the 496 industrial sectors in the 1972 BEA national I-O table. More specifically, RIMS II multipliers can be used to estimate changes in total regional output, earnings, and employment resulting from changes in regional final demand or final payments.

One of the principal advantages of RIMS II for impact estimation is its disaggregated industrial scheme. For example, based on RIMS II multipliers, $1 million of new warehouse construction in the Denver-Boulder, Colorado SMSA would increase personal earnings in the SMSA by $.7 million; the same expenditure in the Wilmington, North Carolina SMSA would increase earnings there by $.5 million. The difference between the earnings impacts in the two SMSA's occurs because the Denver-Boulder economy locally provides more of the total input requirements for constructing warehouses than does the Wilmington economy.

Multipliers are generally smaller in smaller regional economies, and Wilmington is smaller than Denver-Boulder. However, multipliers and estimated regional impacts also depend on which industry is initally affected. For example, if the initial $1 million were spent on the maintenance and repair of streets in Wilmington, the earnings effect there would be $.7 million, which is the same amount as the effect of a $1 million expenditure for warehouse construction in the larger Denver-Boulder SMSA.

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[1] For a more extensive description of RIMS and RIMS II, see Cartwright, et al. (1981).

RIMS II Methodology (Demand-Driven)

In order to estimate impacts such as those presented above, RIMS II uses the 1972 BEA national I-O table, which shows the input and output structure of 496 industries. Since firms in all national industries are not found in each region, some input requirements in a particular region typically cannot be supplied by that region's industries. Input requirements that are not produced in a study region can be identified, using BEA county earnings data. The earnings data are used as proxies for industry-specific input and output data, which are seldom available at the small-area level. Using the same earnings data, the resulting regional I-O table then can be aggregated to the level of industrial detail appropriate for the impact study.

More specifically, the RIMS II approach can be viewed as a three-step process. In the first step, the national I-O coefficient matrix is made region-specific by using location quotients (LQ's).[2] The LQ's are used to

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[2] An earnings LQ is the proportion of total area earnings originating in an industry divided by the proportion of total national earnings originating in the same industry. In the following equation, the superscripts r and n refer to the region and Nation, respectively.

$$LQ_i = \frac{E_i^r / \sum_i E_i^r}{E_i^n / \sum_i E_i^n} \qquad (3.1)$$

An LQ less than (greater than) 1.0 means that the output of a regional industry represents a smaller (larger) share of regional economic activity when compared with the share of national economic activity accounted for by the same industry. For industry i, an LQ less than (greater than) 1.0 often is viewed as indicating than a particular region is an importer (exporter) of the output of industry i.

estimate the extent to which the region's requirements are supplied by firms within the region. For this purpose, RIMS II employs LQ's based on two types of data. BEA county personal income data, by place of residence, are used for the calculation of LQ's in the trade and service-type sectors, while BEA earnings data, by place of work, are used for the LQ's in the other sectors.

The second step involves estimations of the household row and the household column of the matrix. The household-row coefficients are estimated, based on ratios of value added to gross output from the national I-O table, and are then introduced into each industry's coefficient column. A household column is constructed, based on national consumption patterns and national savings rate data, as well as national and regional tax rate data.

The first two steps estimate the regional purchase coefficients matrix (A^r) without estimating regional gross output (X^r), the interindustry transactions matrix (X^r_{ij}), total final payments (FP^r), or total final demand (FD^r). In the final step, based on the estimates of A^r, $(I - A^r)^{-1}$ is calculated, with or without an endogenous household sector, as appropriate for the particular analysis. The inverse matrix shows output multipliers, which can be converted to personal earnings multipliers and employment multipliers, using equations 2.15 and 2.16.

Tests of the accuracy of RIMS II regional purchase coefficients and multipliers indicate that RIMS II yields estimates that are not subtantially different from those generated by regional I-O models based on costly survey data. For example, a comparison of 224 industry-specific multipliers for Texas, Washington, and West Virginia indicates that the RIMS II average multipliers overestimate the average multipliers from the survey-based tables by approximately 5 percent. For the majority of industry-specific multipliers, the difference between RIMS II and survey-based multipliers is less than 10 percent. In addition, RIMS II and survey multipliers show statistically similar distributions of affected industries.

There are numerous advantages to RIMS II. First, it is possible to provide estimates of economic impacts without building a complete survey I-O model for each region under study, since RIMS II produces multipliers that are derived from secondary data sources. Second, the secondary data sources are limited in number, thus eliminating the costs associated with the compilation of data from numerous sources. Third, because of the relatively disaggregated sectoring plan employed by RIMS II, analysis may be performed at a detailed industrial level, thereby avoiding aggregation errors that often occur when different industries are combined. Fourth, the RIMS II multipliers are based on a consistent set of procedures across areas, thus making comparisons among areas more meaningful than results obtained from incompatible impact models designed for specific areas.

The industrial output, earnings, and employment impacts estimated by RIMS II can be crucial for estimating effects not directly specified by RIMS II itself. For example, the estimation of regional fiscal, labor migration, and environmental effects often depends on the estimation of the regional output, earnings, and employment impacts of the initial stimulus. Since many of these important effects are often best analyzed on a case-by-case basis, one of the major advantages of using RIMS II is that valuable research resources can be spent on the analysis of these effects, rather than on the construction of an impact model. Therefore, by using RIMS II, a cost-effective impact study could devote most of its research budget in specifying initial impacts in industry-specific detail, and analyzing the implications for other important aspects of regional economic activity of the RIMS II-estimated economic impacts.

RIMS II multipliers, like the original RIMS multipliers, can be used in various types of impact studies. For example, the NRC has used RIMS and RIMS II multipliers in the environmental impact statements required for building nuclear electricity-generating facilities. The U.S. Department of Housing and Urban Development has used RIMS multipliers to assess the effects of various types of urban redevelopment expenditures. Specifically, BEA was able to quantify probable regional impacts based on the size, type, and location of the initial expenditure.[3] In addition, BEA has provided updated RIMS and RIMS II multipliers to numerous individuals and groups outside the Federal Government. These multipliers have been used in analyzing the regional economic impacts of various projects, such as the operation of a prototype coal gasification plant, the expansion of port facilities, the reclamation of strip-mined land, the consideration of alternative energy futures, the construction of mass transit facilities, and the distribution of payments for regional economic development or redevelopment.

READ uses RIMS II multipliers in assessing the regional impact of cutbacks in military-base spending proposed by the Department of Defense (DOD). In this application, region-specific information is obtained, identifying the local purchases made by a military base and its personnel, as well as the wages and salaries paid to local residents employed on the base. These expenditures are treated as changes in final demand, and are used in generating the industry-specific estimates of impacts associated with the proposed cutbacks. The methodology developed specifically for this application, as well as the basic RIMS II methodology, has been adopted for use by DOD in all future analyses

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3. For a discussion of the methodology and results of this study, see Cartwright (1980).

of the regional economic impacts of proposed major cutbacks.[4] Recently, the growth impacts of increased military expenditures also have been analyzed with RIMS II.

RIMS II Methodology (Supply-Constrained)

As indicated in the discussion of the basic RIMS II methodology, the regional purchase coefficients matrix (A^r) is estimated without estimating the gross output vector (X_j^r), the interindustry transactions matrix (X_{ij}^r), the total final payments vector (FP_j^r), and the total demand vector (FD_i^r). In constrast, for estimating the direct regional sales coefficient matrix (B^r), the transactions matrix and other vectors are required.[5] However, this complication can be overcome by estimating the regional gross output vector using the same industry-earnings data that were used to construct the LQ for the demand-driven RIMS II model.[6]

$$X_j^r = E_j^r \left(\frac{X_j^n}{E_j^n} \right) \tag{3.2}$$

In the above equation, the reciprocal of the national earnings-output ratio is used with data on regional earnings to provide an estimate of regional output. In RIMS II, regional output can be estimated for 496 industries. Estimating regional output at this level of industrial detail should correct for many of the regional differences in earnings-output ratios that exist at a more aggregate level of industrial detail. This correction occurs in much the same way that 496 LQ's correct for industry-mix problems in the estimation of the regional purchase coefficient matrix (A^r).[7]

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[4] For a discussion of the methodology and results of this study, see Cartwright and Beemiller (1980).

[5] Another possibility would be to take the national sales coefficient matrix, and regionalize it with LQ's in the same way that the national purchase coefficient matrix is regionalized to estimate the regional purchase coefficient matrix. However, as shown in the next chapter, estimating first a full regional transactions matrix is essential for the analysis of the industry-specific economic effects of disasters.

[6] In the future, another methodology for estimating industry-specific output could be based on the estimates of gross State product being developed at BEA. Alternatively, these estimates could be used as a basis for testing the accuracy of the industry-specific outputs estimated by equation 3.2.

Based on the estimates of industry-specific output (X_j^r) and the regional purchase coefficients matrix (A^r), the interindustry portion of the regional transactions matrix can be estimated by the following equation, which is simply a reexpression of equation 2.2:

$$X_{ij}^r = a_{ij}^r X_j^r \qquad (3.3)$$

Similarly, regional total final demand can be estimated by a reexpression of equation 2.1, as shown in the following equation:

$$FD_i^r = X_i^r - \sum_j X_{ij}^r \qquad (3.4)$$

Finally, total regional final payments can be estimated by a reexpression of equation 2.8:

$$FP_j^r = X_j^r - \sum_i X_{ij}^r \qquad (3.5)$$

Based on equation 3.4, the supply matrices (equations 2.9 through 2.14) can be estimated.

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[7] For a more extensive discussion on aggregation problems, see Cartwright, et al. (1981), pages 16-17 and chapter 5.

Three observations on the accuracy of the above methodology should be made. First, region-Nation differences in productivity (as measured by the earnings-output ratios) will affect the estimates of regional output. Nevertheless, using 496 industry-specific productivity ratios addresses the industrial-mix aspect of regional productivity differences. Second, the estimates of interindustry transactions (X^r_{ij}) depend additionally on the accuracy of A^r. As indicated above in the discussion of the accuracy of the demand-driven RIMS II model, RIMS II regional purchase coefficient matrices compare favorable with those from survey-based tables.[8]

Third, an indirect test of the overall accuracy of the methodology for estimating a full transactions matrix is based on the I-O accounting identity that nonhousehold final demand should be greater than or equal to zero when imports are treated as a row industry, as they are in RIMS II.[9] For the three case studies presented in chapters 6, 7, and 8, negative nonhousehold final demand represented 2.7 percent of regional total gross output. In each of the three study areas, the same small group of industries had the largest negative nonhousehold final demands.[10] This indicates a small, but systematic, bias in the RIMS II methodology, the causes of which merit further research. In fact, since negative nonhousehold final demand primarily represents an underestimation of imports and, therefore, an overestimation of regional

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8. For additional details, see Cartwright, et al. (1981), chapter 5.

9. In I-O accounting, if nonhousehold final demand is negative, then imports have been underestimated. For a detailed discussion of I-O accounting, see Miernyk (1965), Richardson (1972), Schaffer (1976), and Cartwright, et al. (1981). For an alternative treatment of imports, see Ritz (1980).

10. These industries were maintenance and repair construction, apparel, eating and drinking establishments, insurance, personal services, and other miscellaneous services.

self-sufficiency, the bias may account for the slight overestimation of RIMS II demand-driven multipliers when compared with multipliers derived from more survey-based regional tables.

Chapter 4

A GENERAL MODEL OF THE INDUSTRIAL IMPACTS OF DISASTERS

This chapter presents a general methodology for the analysis of the industrial impacts of disasters. Specific emphasis is given to the industrial impacts of possible nuclear reactor accidents. Detailed assumptions, specific to the impacts of reactor accidents for three case studies, are presented in chapter 5.

Chapter 4 is divided into four sections. The first section provides an overview of the industrial impact model. The second section shows how an intraregional I-O table, which is the basis of the model, can be estimated. The third section indicates how the intraregional I-O model can be used to estimate industry-specific effects of disasters. The final section describes several other aspects of the model and concludes by summarizing the types of effects the model estimates.

Overview of the Model

Three major aspects of the methodology should be mentioned at the outset. First, the analysis is based on the most likely vector of wind-carried radiation due to one type of reactor accident that causes contamination of productive capacity for varying lengths of time.[1] The analysis attempts to identify and measure the regional industrial output (and associated personal earnings and employment) that might be affected by the accident.

Second, only the first-year industrial impacts are estimated. The longer-term potential economic effects of increased morbidity and mortality, decreased regional investment, and increased outmigration of population are not discussed. Longer-term effects are especially difficult to specify ex ante, because they depend on the severity of the accident, the mitigating actions (for example, evacuation) taken immediately after the accident, and the effort taken to decontaminate the physically affected area. Immediate mitigation and longer-term decontamination are undertaken in response to the specific characteristics of an accident, which are better known only after an accident occurs.

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[1] A wind vector refers to the direction toward which the wind is blowing. Work is underway on analyzing numerous wind vectors for varying severities of accidents. Such an extension represents a generalization of the methodology presented here.

Third, an economic study area (figure 4.1) is defined to consist of a physically affected area and a physically unaffected area. The industrial impacts estimated in this paper are for the study area as a whole, since an accident could cause a decline in output (for example, agricultural output) in the physically affected area, which then could affect output (for example, food processing) in the physically unaffected area.[2]

A two-part technique is used to estimate the regional industrial impacts of a nuclear reactor accident. First, based on NRC-supplied information on wind patterns and contamination levels,[3] a physically affected area is defined, and losses in economic output are estimated. Second, the losses in output in the physically affected area are used to estimate demand-driven impacts and to indicate potential supply-constrained vulnerabilities in the physically unaffected part of the study area.

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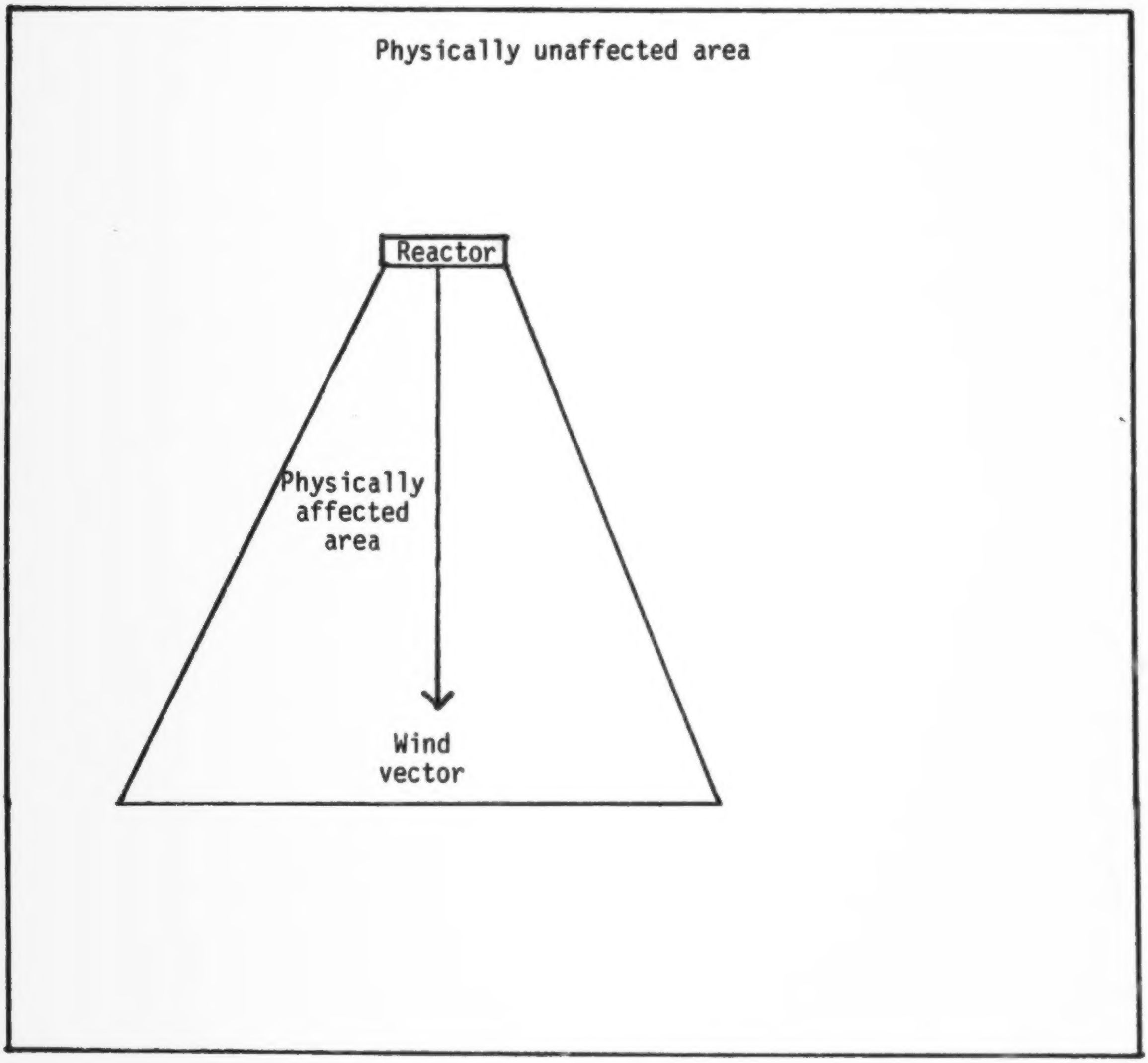
2. An additional reason for estimating regional economic impacts beyond the physically affected area is that, even though productive capacity there may be lost for one year or more, sufficient productive capacity may be available in the physically unaffected area so that output may not change for the study area as a whole.

3. General characteristics of nuclear reactor accidents are described by Pasedag, et al. (1981), and NRC (1975). Additional information was supplied by the Siting Analysis Branch within the Office of Nuclear Reactor Regulation of NRC. This information is summarized in chapter 5; see also tables 6.4, 7.4, and 8.4.

Figure 4.1.--Hypothetical Study Area


Physically unaffected area
Reactor
Physically affected area
Wind vector

The general characteristics of the industrial impact model can be presented in terms of the same hypothetical economy discussed in chapter 2. Table 4.1 shows how industry-specific output could be affected by a hypothetical accident. In the table, study area output (X^s) is classified as to whether it takes place in the physically affected area (a) or the physically unaffected area (u). The largest direct output effect in the study area as a whole occurs in the manufacturing industry, followed by smaller effects in agriculture and trade. No direct effects occur in the study area's construction or services industries, since these industries are not present in the physically affected area.[4] Table 4.1 also shows output location quotients calculated for each of the two subareas with respect to the study area as a whole. That is,

$$LQ_i^u = \frac{X_i^u \,/\, \sum_i X_i^u}{X_i^s \,/\, \sum_i X_i^s} \qquad (4.1)$$

$$LQ_i^a = \frac{X_i^a \,/\, \sum_i X_i^a}{X_i^s \,/\, \sum_i X_i^s} \qquad (4.2)$$

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[4] As indicated in chapter 5, there are various types of physical impacts on industrial output. For example, in the area immediately surrounding the reactor, all industrial output would cease for more than one year, while only certain types of agricultural production would be affected in more distant areas. In these latter areas, only affected agricultural production is included in "affected output;" other types of production, those that are unaffected, are included in "unaffected output." Therefore, the terms, "affected areas" and "unaffected areas," are not purely spatial in meaning.

Table 4.1.--Hypothetical Accident Scenario
(Millions of dollars)

	Study area	Physically unaffected area			Physically affected area		
	X^s	X^u	X^u / X^s	LQ^u	X^A	X^a / X^s	LQ^a
Agriculture (1)	70	56	.80	.94	14	.20	1.33
Construction (2)	90	90	1.00	1.18	0	0	0
Manufacturing (3)	105	63	.60	.71	42	.40	2.67
Trade (4)	72	64.8	.90	1.06	7.2	.10	.67
Services (5)	70	70	1.00	1.18	0	0	0
Total	**407**	**343.8**	**.85**	- - -	**63.2**	**.15**	- - -

Having first specified the total study area's imports and exports, an $LQ_i^{u \text{ (or } a)}$ less (greater) than 1.0 can be interpreted as meaning that one subarea is importing from (exporting to) the other subarea the output of industry i. The LQ's in table 4.1 can be interpreted as indicating that the unaffected area exports construction, trade, and some services to the affected area, and that the affected area exports some agriculture and some manufacturing to the unaffected area. Furthermore, the sizes of the LQ's indicate, for example, that the unaffected area is nearly self-sufficient in agriculture (since its LQ is close to 1.0), but is less self-sufficient in manufacturing. The LQ's also indicate that if one part of the study area imports (exports) the output of any industry, then the other part of the study area exports (imports) that output.

Before the occurrence of a disaster, the actual volume of intrastudy-area trade might be larger than that implied by these LQ's. For example, the physically unaffected area could be exporting agriculture (even though its LQ is less than 1.0) as an input to industries in the physically affected area, while the physically unaffected area could be exporting agriculture to the unaffected area. That is, crosshauling, which refers to an economy simultaneously importing and exporting the same commodity, could be extensive between the two parts of the study area.[5/] In the aftermath of a disaster, crosshauling would be eliminated; supplying industries in the unaffected area would sell, to the greatest extent possible, to other industries in the unaffected area. To continue the above example, agricultural inputs, produced in the unaffected area but previously sold to the affected area, would be available to industries in the unaffected area that were no longer able to purchase agricultural inputs

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[5] For discussions of crosshauling, see Hoover (1971) and Richardson (1972). For a discussion of the assumptions required when using LQ's for identifying imports and exports, see Glickman (1977), Cartwright (1979), and Cartwright, et al. (1981), pages 15-18.

from the affected area. Therefore, LQ's, often criticized for not taking into account crosshauling, are especially appropriate for identifying intraregional trade in the analysis of disasters when the possibility of crosshauling has been eliminated.

Based on the above interpretation of the LQ's in table 4.1, if the physically affected area requires any inputs from the construction or services industries, then it must import these inputs from the unaffected area. (The affected area would also import some of its trade inputs from the unaffected area.) Clearly, output decreases in the affected area could lead to decreases in its demand for imports from the unaffected area. Thus, even though no direct effects occurred in construction or services in the study area, indirect effects could occur in these industries. The impacts caused by a decrease in exports of the unaffected area to the affected area should be estimated by a demand-driven I-O model for the unaffected area.

In table 4.1, the 2.67 LQ for manufacturing indicates that manufacturing accounts for a larger share of total output in the affected area than in the study areas as a whole. Therefore, the affected area, in addition to providing a part of the total study area's manufacturing exports, supplies some manufacturing output to the physically unaffected area. This would indicate that the industries requiring manufacturing inputs in the physically unaffected area are vulnerable to supply constraints when manufacturing output is lost in the physically affected area. Such impacts could be estimated by a supply-constrained I-O model for the unaffected area.[6]

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[6] For the reasons mentioned in the concluding section of chapter 2, supply vulnerabilities are not estimated by supply-constrained multipliers. The specific difficulties in estimating supply constraints for the hypothetical accident described in table 4.1 are discussed in the third section of chapter 4. For the case studies, several potential vulnerabilities are indicated; see tables 6.7, 7.7, 7.8, and 8.7.

To summarize, in addition to the direct output losses due to physical contamination of productive capacity in the physically affected area, indirect industrial impacts can occur in the physically unaffected area due to (1) cessation of exports to the affected area and (2) unavailability of imports from the affected area. Not all of the output losses in the affected area are likely to influence the unaffected area, since some of the lost output might have been sold as intermediate inputs to industries in the affected area, or exported outside the study area. Therefore, the analysis of disasters affecting a number of industries requires identifying both the initial interindustry effects in the physically affected area and the "spillover" effects (in terms of exports and imports) in the physically unaffected area.[7]

Estimation of an Intraregional I-O Table

The technique used to identify and measure interindustry effects within the physically affected area and spillover effects in the physically unaffected area is intraregional I-O analysis.[8] To illustrate this analysis, first let the study area's I-O table be represented by the following equation (a restatement of equation 2.1):

$$X_i^s = \sum_j X_{ij}^s + FD_i^s \tag{4.3}$$

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[7] For the case studies presented in chapters 6, 7, and 8, it should be pointed out that spillover effects are relatively small when compared with the direct losses in output in the physically affected area.

[8] Cartwright (1979) develops a RIMS-based methodology for estimating intrametropolitan multipliers for a study area composed of two parts--a central city and a surrounding suburb. Cartwright (1980) presents the results of applying this methodology to 20 metropolitan areas. For additional references to intraregional and interregional analysis, see Richardson (1972), Stanback and Knight (1976), Glickman (1977), Ballard, et al. (1980), and Kort and Cartwright (1981).

If a study area is viewed as made up of two parts--a physically affected area and a physically unaffected area--then an intrastudy-area I-O table, which shows intraregional economic activity between the two subareas, can be represented by the following equations:

$$\left[\begin{array}{c} X_i^u \\ \hline X_i^a \end{array}\right] = \left[\begin{array}{cc} X_{ij}^{uu} & X_{ij}^{ua} \\ \hline X_{ij}^{au} & X_{ij}^{aa} \end{array}\right] + \left[\begin{array}{c} FD_i^u \\ \hline FD_i^a \end{array}\right] \tag{4.4}$$

$$X_i^s = X_i^u + X_i^a \tag{4.5}$$

$$X_{ij}^s = \begin{bmatrix} X_{ij}^{uu} & X_{ij}^{ua} \\ X_{ij}^{au} & X_{ij}^{aa} \end{bmatrix} \tag{4.6}$$

$$FD_i^s = FD_i^u + FD_i^a \tag{4.7}$$

where:

X_{ij}^{rt} = the output of industry i produced in region r, and sold to industry j located in region t

In the above equations, the superscripts (u and a) refer to the physically unaffected and affected areas, respectively. In matrix notation, X^{uu} and X^{aa} refer to the interindustry transactions within each part of the study area. X^{au} and X^{ua} represent intrastudy-area trade; specifically, X^{au} represents imports by the unaffected area from the affected area and X^{ua} represents exports of the unaffected area to the affected area.

In the aftermath of a reactor accident, when intrastudy-area trade would cease, the values in the two inter-subarea trade matrices provide estimates of the initial effects in the unaffected area. X^{ua} shows the unaffected area's output that will no longer be demanded by the affected area, and X^{au} shows the imports to the unaffected area that will no longer be supplied by the affected area. Therefore, X^{ua} represents a final demand change with respect to the unaffected area, and the impacts of this change can be estimated by a demand-driven multiplier matrix--$(I - A^{uu})^{-1}$--for the unaffected area. Similarly, X^{au} represents an import contraint, and the impacts of this constraint could be estimated by a supply-constrained multiplier matrix--$(I - B^{uu})^{-1}$--for the unaffected area.

The matrices and vectors in equations 4.4 through 4.7 can be estimated by a methodology similar to that used to estimate a study area's I-O table, based on the national table. That is, LQ_i^u and LQ_i^a can be used to regionalize further the study area's purchase coefficients (a_{ij}^s).[9] This can be represented by the following four equations:

$$a_{ij}^{uu} = r_i^u \, a_{ij}^s \tag{4.8}$$

$$a_{ij}^{au} = a_{ij}^s - a_{ij}^{uu} \tag{4.9}$$

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[9] Further regionalizing a regional table (whether the large region table is survey or nonsurvey based) is often a useful technique. For example, in order to estimate multipliers for Chelan County, Washington, the survey-based 1972 Washington State table was regionalized with county-specific LQ's by Bare, et al. (1978). Mulkey and Hite (1978) developed a nonsurvey procedure for estimating a two-region I-O table, in which the impact region appears as an endogenous submatrix in the national I-O table. Also see Cartwright (1979).

$$a_{ij}^{aa} = r_i^a \, a_{ij}^s \tag{4.10}$$

$$a_{ij}^{ua} = a_{ij}^s - a_{ij}^{aa} \tag{4.11}$$

where:

r_i^u = LQ_i^u, if LQ_i^u is less than 1.0

r_i^u = 1.0, if LQ_i^u is greater than or equal to 1.0

r_i^a = LQ_i^a, if LQ_i^a is less than 1.0

r_i^a = 1.0, if LQ_i^a is greater than or equal to 1.0

The interpretation of these equations can be illustrated by an example. If r_i^u is less than one, and industry j uses the output of industry i, then industry j in the unaffected area would purchase some of that input from the affected area.

Using the technique presented in equations 3.3 through 3.5, the intraregional system summarized in equations 4.4 through 4.7 can be fully developed. That is,

$$X_{ij}^{uu} = a_{ij}^{uu} \, X_j^u \tag{4.12}$$

$$X_{ij}^{au} = a_{ij}^{au} \, X_j^u \tag{4.13}$$

$$X_{ij}^{aa} = a_{ij}^{aa} \, X_j^a \tag{4.14}$$

$$X_{ij}^{ua} = a_{ij}^{ua} \, X_j^a \tag{4.15}$$

$$FD_i^u = X_i^u - \sum_j X_{ij}^{uu} - \sum_j X_{ij}^{ua} \quad (4.16)$$

$$FD_i^a = X_i^a - \sum_j X_{ij}^{aa} - \sum_j X_{ij}^{au} \quad (4.17)$$

$$FP_j^u = X_j^u - \sum_i X_{ij}^{uu} - \sum_i X_{ij}^{au} \quad (4.18)$$

$$FP_j^a = X_j^a - \sum_i X_{ij}^{aa} - \sum_i X_{ij}^{ua} \quad (4.19)$$

Based on the above equations and the data in tables 2.1 and 4.1, table 4.2, which shows the full intrastudy-area I-O table, was developed. The transactions table indicates that the physically affected area purchases all of its construction and services intermediate inputs from the unaffected area, but purchases only a third of its trade inputs from the unaffected area. The table also shows that the affected area supplies 29 percent of the unaffected area's intermediate demand for manufacturing, but only 6 percent of the unaffected area's agricultural inputs.

Estimated Intrastudy-Area Impacts

Impacts in the physically affected area can be estimated by either a demand-driven or supply-constrained model for the affected area. That is, in matrix notation,

$$X^a = (I - A^{aa})^{-1} (\Delta FD^a + \Delta X^{au}) \quad (4.20)$$

$$X^a = (\Delta FP^a + \Delta X^{ua}) (I - B^{aa})^{-1} \quad (4.21)$$

The two equations are similar to equations 2.7 and 2.14, respectively. Because equations 4.20 and 4.21 represent I-O relationships only for the affected part

Table 4.2.--Hypothetical Intraregional Transactions Table

(Millions of dollars)

			Purchasing industry										Final demand	Total outputs
			Unaffected area					Affected area						
			(1u)	(2u)	(3u)	(4u)	(5u)	(1a)	(2a)	(3a)	(4a)	(5a)		
Selling industry	Unaffected area	Agriculture (1u)	7.5	4.7	2.8	1.7	0	0	0	0	0	0	39.3	56.0
		Construction (2u)	4.0	20.0	9.0	4.5	5.0	1.0	0	6.0	.5	0	40.0	90.0
		Manufacturing (3u)	5.7	21.3	12.8	6.4	7.1	0	0	0	0	0	9.7	63.0
		Trade (4u)	4.0	10.0	6.0	13.5	10.0	.3	0	1.3	.5	0	19.2	64.8
		Services (5u)	12.0	5.0	3.0	18.0	5.0	3.0	0	2.0	2.0	0	22.0	70.0
	Affected area	Agriculture (1a)	.5	.3	.2	.1	0	2.0	0	2.0	.2	0	8.7	14.0
		Construction (2a)	0	0	0	0	0	0	0	0	0	0	0	0
		Manufacturing (3a)	2.3	8.7	5.2	2.6	2.9	2.0	0	12.0	1.0	0	5.3	42.0
		Trade (4a)	0	0	0	0	0	.7	0	2.7	1.0	0	2.8	7.2
		Services (5a)	0	0	0	0	0	0	0	0	0	0	0	0
		Final payments	20.0	20.0	24.0	18.0	40.0	5.0	0	16.0	2.0	0		
		Total inputs	56.0	90.0	63.0	64.8	70.0	14.0	0	42.0	7.2	0		

of the total study area, output exported to the unaffected area (X^{au}) is viewed as a demand change, and inputs imported from the unaffected area (X^{ua}) are viewed as a supply constraint. Both equations generate output losses of \$14.0 million in agriculture, \$42.0 million in manufacturing, and \$7.2 million in trade.[10]

The results obtained by using either equation 4.20 or 4.21 do not provide an estimate of the total industrial impacts of the hypothetical accident. That is, in addition to the impacts in the physically affected area, impacts will occur in the physically unaffected part of the study area. These impacts could be estimated by the following equations:

$$\Delta X^{u} = (I - A^{uu})^{-1} (\Delta FD^{u} + \Delta X^{ua}) \tag{4.22}$$

$$\Delta X^{u} = (\Delta FP^{u} + \Delta X^{au}) (I - B^{uu})^{-1} \tag{4.23}$$

If final demand and final payments did not change in the physically unaffected area, the two trade matrices (X^{au} and X^{ua}) alone could indicate industrial

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[10] As discussed in chapter 2, either a total collapse of demand or supply can reduce regional output to zero. Again, the impacts are not additive. For the hypothetical accident scenario presented in this chapter,

$$\Delta FD^{a} + \Delta X^{au} = \begin{bmatrix} -8.7 & + & -1.1 \\ 0 & + & 0 \\ -5.3 & + & -21.7 \\ -2.8 & + & 0.0 \\ 0 & + & 0 \end{bmatrix}$$

and

$$\Delta FP^{a} + \Delta X^{ua} = \begin{bmatrix} -5.0 & + & -4.3 \\ 0 & + & 0 \\ -16.0 & + & -9.3 \\ -2.0 & + & -3.0 \\ 0 & + & 0 \end{bmatrix}$$

impacts there.[11] Based on the loss of exports to the physically affected area, equaling $7.5 million in construction, $2.1 million in trade, and $7.0 million in services, the total demand-driven decreases in output in the physically unaffected area would be $1.3 million in agriculture, $12.6 million in construction, $6.2 million in manufacturing, $7.3 million in trade, and $11.1 million in services.[12]

Furthermore, due to the inability to import inputs from the affected area, supply constraints could curtail output in the unaffected area. As shown in table 4.2 by the X^{au} portion of the study area's I-O table, each industry in the unaffected area imports some manufacturing inputs from the affected area, and four industries import agricultural inputs from the affected area. The total value of these imports is $1.1 million for agriculture and $21.7 million for manufacturing. For a number of reasons (some of which are discussed in general terms in chapter 2), however, supply-constrained impacts in practice cannot be estimated by equation 4.23. First, supply constraints would take place only if industries in the unaffected area were unable to locate another source of inputs outside the study area.

A second complicating factor is that the production of required inputs, no longer available from the affected area, could increase in the unaffected area if excess capacity existed there. If, for example, the unaffected area would increase its output of manufacturing by 10 percent (or $6.3 million), then the value of required manufacturing inputs could decrease from $21.7 million to $15.1 million. For the case studies analyzed in chapters 6, 7, and 8, manufacturing output in the unaffected area is permitted to expand to maximum desired capacity, agricultural output is assumed to be unable to expand in the one-year timespan adopted for the studies, and output in all other industries in the unaffected area is assumed to be able to compensate (given sufficient demand) for output lost in the affected area.

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[11] It is not unreasonable to assume that final demand and final payments do not change in the physically unaffected area, since the rest of the Nation would still want as exports part of the output of the study area. The circumstances under which final demand for the output of the unaffected area would change are discussed in the concluding section of this chapter.

[12] These decreases in output would occur if there were no compensating final demand changes for the output of the unaffected area; see the discussion of the assumptions of demand-driven multiplier matrices in chapter 2.

A third complicating factor is that demand-driven and supply-constrained impacts are not additive. As presented above in the discussion of equation 4.22, the indirect effects on the unaffected area's output of decreased exports to the affected area would be $1.3 million in agriculture and $6.2 million in manufacturing. These output losses represent inputs that would be available to industries in the unaffected area. In this hypothetical scenario, lost agricultural output ($1.3 million) would more than cancel the need to import the agricultural inputs ($1.1 million) no longer available from the affected area. Similarly, lost manufacturing output ($6.2 million) would decrease further the value of required manufacturing imports, from $15.1 million to $8.9 million. For the case studies presented in chapters 6, 7, and 8, demand-driven output losses in the unaffected area are permitted to compensate for imported inputs no longer available from the affected area.

A fourth complicating factor is that the scarce manufacturing output could be reallocated (through the price mechanism or central planning) among the industries in the unaffected area. For example, the construction industry, which is both the largest user of manufacturing inputs and the largest industry in the unaffected area, could be given all of its required manufacturing inputs from the available supply. Another possibility would be to permit manufacturing final demand, rather than intermediate demand, to be reduced. In general, this would generate a higher level of post-accident earnings and employment in a study area. For example, in the analysis of a possible accident at the St. Lucie reactor (described in chapter 6), one of the major impacts is on citrus output. Clearly, earnings and employment in the frozen citrus juice industry in the study area could be better maintained if that industry received as much as possible of the available citrus fruits and if exports of unprocessed citrus fruits absorbed as much as possible of the output decrease. Based on this complicating factor, even the few supply vulnerabilities specified in the case studies might not occur.

A final complicating factor is that one of the two potential sources of supply constraints that have been identified may be more binding than the other. For the hypothetical example, the scarcity of manufacturing inputs would be expected to have a larger constraining effect on output in the unaffected area than would the scarcity of agricultural inputs. Furthermore, the indirect decreases in output that could occur in any of the unaffected area's industries because of a manufacturing-induced supply constraint would lead to a decreased intermediate demand for agricultural imports.

Although the size of supply-constrained impacts on output are difficult to estimate precisely, some inferences can be made concerning the importance of supply constraints in the hypothetical example. Constraints due to a decrease in the availability of agricultural inputs are unlikely to occur because (1) previously, only a small amount of agriculture was imported from the physically affected area, and (2) intermediate demand for agricultural inputs would decline due to decreased exports to the affected area or to constraints arising from the decreased availability of manufacturing inputs. In constrast with agriculture, the potential decrease in the availability of manufacturing inputs could directly constrain the output of each of the five industries in the unaffected area, because (1) manufacturing inputs from both parts of the study area represent between 14 and 33 percent of each industry's total inputs, and (2) the decreased availability of manufacturing inputs (between \$21.7 million and \$8.9 million) represents between 29 and 10 percent of total intermediate demand for manufacturing in the physically unaffected area.

In the three case studies, the decreased availability of inputs (due to the inability of the unaffected area to import from the affected area) typically does not directly affect every industry's output. Compared with the hypothetical example, the case studies are based on far more disaggregated industrial classifications; in these studies, an unavailable input (for example, certain agricultural commodities) typically directly affects only a few industries (for example, certain food and kindred product manufacturers).[13] When disaggregated industrial classifications are used, the vulnerability of an industry's output to the unavailability of a given amount of an input can be estimated by the following equation:

$$VX_j = \left(\frac{NX_{ij}}{DX_{ij}} \right) X_j \tag{4.24}$$

where:

VX_j = vulnerable output in j

NX_{ij} = input of i not available to j

DX_{ij} = total demand by j for i

X_j = total output of j

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13. The use of disaggregated industrial classifications also limits the ability of the unaffected area to compensate for lost inputs.

The above equation implies, for example, that if one-tenth of the required input of fabricated structural metal became unavailable to the shipbuilding industry, then one-tenth of the output of shipbuilding would be vulnerable.

Additional Aspects of the Model

Equation 4.22 was used to estimate the demand-driven impacts of an accident in the hypothetical economy; in using the equation, it was assumed that only exports (X^{ua}) from the unaffected to the affected area changed. Final demand (FD^{u}) in the unaffected area might change, however, due to tourist avoidance and household evacuation. Demand by tourists (a component of FD^{u}) who at one time visited the unaffected area from elsewhere in the Nation could decrease due to their avoidance of even the physically unaffected area. Tourist avoidance represents an additional negative impact on the unaffected area's economy. As indicated in chapter 5, trade and services are the two industries most affected by tourism. If expenditures by tourists who avoided the unaffected area were 10 percent of total final demand for the output of these two industries in the unaffected area, then, based on the data in table 4.2, there would be decreases in final demand of $1.92 million for trade and $2.2 million for services. The total effects of these decreases can be estimated by equation 4.22.

Persons who evacuated the physically affected area in the immediate aftermath of an accident could resume their normal consumption expenditures (a part of FD^{a}), but in the unaffected area. Therefore, the households part of the negative final demand change (ΔFD^{a}) in the affected area could result in an equal-sized, but positive, final demand change (ΔFD^{u}) in the unaffected area. Expenditures in the unaffected area by evacuated households represent a compensating positive impact on the unaffected area's economy. This is similar to the compensating effects (in response to potential supply constraints) of increased production by firms in the unaffected area that were operating below maximum desired capacity before the accident. Whereas increased capacity-utilization rates represent increased supply in the unaffected area, expenditures by evacuated households represent increased demand. For example, if 50 percent of the final demand for trade in the affected area represented expenditures by households in the affected area, then, based on data in table 4.2, there would be a positive change in final demand for trade in the unaffected area of $1.4 million, if evacuated households resumed their expenditures in the unaffected area. The total effects of this change can be estimated by equation 4.22.[14]

To summarize this chapter, the general model of the impact of disasters should be viewed as providing estimates of the following types of impacts that could occur in a region, for example, after an accident at a nuclear reactor:

(1) direct losses in the physically affected area;

(2) indirect losses in the physically unaffected area due to (a) decreased exports (X^{ua}), (b) tourist avoidance (part of FD^{u}), and (c) supply constraints (X^{au}); and

(3) compensating gains in the physically unaffected area due to (a) increased output (ΔX^{u}), and (b) increased demand (ΔFD^{u}) by evacuated households.

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14. However, as presented in the case studies in chapters 6, 7, and 8, the total effects of evacuated households resuming normal consumption expenditures in the unaffected area are constrained by the capacity available in the unaffected area. This implies that imports from the rest of the Nation will rise to satisfy demand by evacuated households. Furthermore, the case studies are based on the assumption that output in trade and service industries can increase up to the level of demand. Therefore, for example, retail food purchases in the unaffected area by evacuated households could take place at the same level as they did in the affected area.

Chapter 5

ASSUMPTIONS ADOPTED FOR THE CASE STUDIES

The purpose of this chapter is to describe specific characteristics of possible nuclear reactor accidents, and to describe how these characteristics can be integrated with the general model developed in the preceding chapter. The assumptions on the wind vectors, the various types of contamination, and the extent of tourist avoidance were supplied by NRC. The definitions of the study areas surrounding the physically affected areas in the case studies were adopted after consultation with NRC. This chapter also discusses how estimates of changes in industry-specific output were developed and how rates of capacity utilization were used in estimating the compensating increases in output that might occur in the physically unaffected area. The chapter begins with definitions of economic terms used in the case studies and in the remainder of this chapter.

Economic Terms

Since the estimates of impacts in the case studies are derived from a RIMS II-based I-O methodology, the definition of output is from the I-O accounting system. Output in the I-O system includes all industry sales, whether to intermediate or final demand. Output in the I-O system does not equal output in the sense of Gross National Product, which refers only to final sales.1/

Earnings (a component of final payments in the I-O system) consist of wages and salaries, other labor income, and proprietors' income.2/

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1. For additional details on I-O accounting, see Ritz (1980); for additional details on regional economic accounting, see Garnick and Grimes (1979).

2. For details on the definitions and measurement of the components of personal income at the regional level, see U.S. Department of Commerce (1980).

Since employment (which reflects persons receiving wages and salaries, and proprietors' income) is defined on an establishment basis in the case studies, employment impacts are expressed in terms of the number of jobs affected. Therefore, a person with two jobs, whether full-time or part-time, is counted twice.

Study Areas

The measurement of the industrial impacts of possible accidents at nuclear power plants requires, at the outset, identifying the severity of an accident, the types of radiation released, the direction and extent of wind-carried radiation, and the types of physical effects caused by the radiation at varying distances from the reactor.[3] The case studies are based on one highly probable wind vector for an SST1 accident scenario.[4] Work is underway within READ to analyze, for numerous wind vectors, accident scenarios of varying severities.

NRC defined the physically affected areas based on the above accident characteristics for each of the case studies. (Since the economic data necessary to specify RIMS II and the general industrial impact model are not available below the county level, all area definitions follow county boundaries.) Four types of physically affected areas, each with its own site-specific mileage limitations, were delineated: (1) total land and asset interdiction; (2) limited land and asset interdiction (decontamination area); (3) crop interdiction; and (4) milk interdiction.

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3. The accident characteristics are estimated by the calculation of the Reactor Accident Consequences (CRAC) model; for additional details on CRAC, see U.S. NRC (1975).

4. SST1 is the designation given by NRC to a "worst-case" accident scenario in which all safety systems fail; for additional details on the various types of accidents, see Pasedag, et al. (1981). For a description of the industrial effects of an actual accident at a nuclear reactor, see Flynn and Chalmers (1980).

The delineation of the total study area for each case study is dependent on the industrial structure of the physically affected area, and the interindustry and interregional linkages it has with the surrounding region. Since the definition of a BEA economic area incorporates these interindustry and interregional linkages, the economically affected areas are generally comprised of groups of BEA economic areas.[5] Those BEA economic areas that have their central SMSA lying within 150-175 miles of the wind vector that originates from the reactor site have been incorporated into the study area. However, this mileage limitation is flexible in that study areas are defined so that direct effects (for instance, agriculture on food processing) are not ignored. A description of the four types of physically affected areas and the surrounding study area is presented for each of the case studies in tables 6.4, 7.4, and 8.4.

Estimating Output Impacts

For the four types of physically affected areas, the length of time that production would be lost by both agricultural and nonagricultural industries was specified by NRC. In addition, NRC provided information on the length of time that tourists would avoid each type of physically affected area and the physically unaffected area. Table 5.1 shows the percent of annual output that would be lost if an SST1 nuclear reactor accident occurred.[6] For example, table 5.1 indicates that dairy output would be lost for 1 year in the interdicted area and for 3 months (25 percent of annual output) in the decontamination area.

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[5] For a complete description of the delineation of the BEA economic areas, see BEA (1978).

[6] According to the NRC-supplied information on an SST1 accident, output in the interdicted area would be affected for more than one year. However, as indicated in chapter 4, only the first year impacts are analyzed in the present version of the industrial impact model.

Table 5.1.--Direct Output Effects Due to an SST1 Nuclear Reactor Accident, by Type of Area

Industry affected	Percent of annual output loss				Percent of annual output loss
	Interdicted	Decontamination	Crop interdicted	Milk interdicted	Physically unaffected
Dairy	100	25	16	16	0
Crops	100	100	100	0	0
Forestry and greenhouse	100	0	0	0	0
Livestock and poultry	100	50	0	0	0
Nonagriculture, excluding tourist avoidance	100	25	0	0	0
Hotels and lodging places, additional effects due to tourist avoidance	0	56	45	45	10

Using the parameters in table 5.1, the output losses of industries located in the physically affected area are estimated by the following equation:[7]

$$X_i^a = \sum_{p=1}^{4} X_i^p T_i^p \qquad (5.1)$$

where:

X_i^a = the output loss on an annual basis in industry i in the total physically affected area

p = 1 for the interdicted area

p = 2 for the decontamination area

p = 3 for the crop interdicted area

p = 4 for the milk interdicted area

X_i^p = one year's output in industry i located in area p

T_i^p = the proportion of a year's output lost in industry i located in area p

Equation 5.1 indicates that total physically affected output is the sum of effects in each of the four types of physically affected area. BEA's cash receipts data are used to estimate X_i^p for the agriculture industries, and BEA's county earnings data and equation 3.2 are used to estimate X_i^p for the nonagriculture industries.[8]

Output losses will also occur in the unaffected area due to tourist avoidance. Furthermore, based on the information supplied by NRC, tourists will avoid the physically affected areas even after other types of economic activity are assummed to have returned to normal levels. The principle industries affected by tourist avoidance are hotels and lodging places, eating and drinking establishments, and other retail trade. Equation 5.2 indicates that the output lost in hotels and lodging places (in addition to that identified for the interdicted and decontamination areas by equation 5.1) is the sum of the amount lost in the physically affected and unaffected areas.

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[7] In the case studies, large direct losses are reported as falling within a percent range of U.S. output to avoid disclosing confidential data.

[8] The data on agricultural cash receipts are based on U.S. Department of Commerce (1977). For a description of the earnings data, see U.S. Department of Commerce (1980).

$$X_n^s = \sum_{p=1}^{4} X_n^p T_n^p + X_n^u T_n^u \qquad (5.2)$$

where:

X_n^s = the total output loss in hotels and lodging places in the study area

X_n^p = one year's output in hotels and lodging places in area p

T_n^p = the proportion of a year's output lost (in addition to that identified by equation 5.1) in hotels and lodging places located in area p

X_n^u = one year's output in hotels and lodging places in the physically unaffected area

T_n^u = proportion of a year's output lost in hotels and lodging places in the physically unaffected area.

X_n^p and X_n^u are estimated by equation 3.2. Based on the tourist-related lost output in hotels and lodging places and on data categorizing consumer expenditures, additional output losses are estimated for eating and drinking establishments and other retail trade.[9]

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[9] Data on vacation and pleasure-trip expenditures indicate that for every dollar spent in hotels and lodging places, $1.55 is spent on eating and drinking and $.26 on retail trade. For additional details, see U.S. Department of Labor (1979). It should be pointed out that the impacts estimated for tourism in the case studies refer to both business-related and recreational tourism.

As discussed in chapter 4, compensating output gains could occur in the physically unaffected area. However, the output gains are confined to the nonagricultural industries since agricultural output is constrained in the short run by the growing cycle. It is assumed that any increase in the demand for the output of nonmanufacturing industries in the unaffected area can be supplied by industries in the unaffected area. However, it is assumed that the lost manufacturing output can be compensated for by manufacturers in the unaffected area only if excess capacity exists there.

Based on the national capacity utilization rates,[10] the following equation can be used to estimate the amount of increased production in manufacturing that might take place in the unaffected area:

$$XP_i^u = \left(\frac{PCR_i^n}{ACR_i^n}\right) X_i^u \qquad (5.3$$

where:

XP_i^u = the potential output of industry i in the unaffected area

PCR_i^n = the national preferred capacity utilization rate in industry i

ACR_i^n = the national actual capacity utilization rate in industry i

X_i^u = the preaccident output of industry i in the unaffected area

The difference between XP_i^u and X_i^u is a measure of the potential increase in manufacturing output in the unaffected area. If the difference exceeds the loss

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[10] Since regional capacity utilization rates are not available, industry-specific national capacity utilization rates are used. In the case studies, the rates are for 1980. For details on capacity utilization rates, see U.S. Federal Reserve System (undated).

(X_i^a) in the affected area, then the loss could be compensated for completely. If the difference between XP_i^u and X_i^u is positive, but does not exceed X_i^a, then the loss could be compensated for only partially. Since the capacity utilization rates underlying the estimate of XP_i^u in the case studies are both national rates and for a given year, some care should be taken in interpreting the sizes of compensated losses in manufacturing employment in the case studies.

Finally, as discussed in chapter 4, compensating impacts on output and employment could occur if households that evacuated the physically affected area resume their consumption expenditures, but in the physically unaffected area. These effects can be estimated by the following equation (a particular case of equation 4.22):

$$\Delta X^u = (I - A^{uu})^{-1} (-\Delta FD_h^a) \qquad (5.4)$$

where:

$$-\Delta FD_h^a = \Delta FD_h^u$$

$$X_i^u + \Delta X_i^u \leq XP_i^u$$

If households resumed consumption expenditures in the unaffected area, then the negative household final demand (ΔFD_h^a) in the affected area would imply an equal-sized, but positive, final demand change (ΔFD_h^u) in the unaffected area. However, the output increases due to additional household expenditures must be consistent with potential output in the unaffected area. In the RIMS II methodology, the size of the final demand change is estimated by equation 3.4 and appears as the household column in the regional transactions table.

Chapter 6

ST. LUCIE NUCLEAR REACTOR

The industrial impact model used to estimate the private-sector effects of a hypothetical accident at the St. Lucie nuclear reactor indicates that the total employment loss in all industries directly affected by the accident could be 80,000 (3.2 percent of the total employment in the economic area surrounding the St. Lucie reactor site). In addition to large direct effects in agriculture (primarily in citrus fruits and vegetables), major impacts could occur in service-type industries. Moreover, impacts associated with a decrease in tourist activity could total an additional annual 7,000 jobs, primarily in eating and drinking places, and in hotels and other lodging places. Finally, the model indicates that indirect industrial effects are generally small, however, up to 30,000 annual jobs in the food and kindred products industry are vulnerable to the decreased availability of agricultural inputs.

Economic Profile

Population and earnings, 1969-78

On July 1, 1978, the population of the study area[1] was 6.7 million, representing almost 78 percent of Florida's total population (table 6.1). From 1969 to 1978, population increased faster in the study area (32.7 percent) than it did in the State as a whole (29.4 percent), reflecting South Florida's rapid increase in inmigration (table 6.2). The study area grew almost four times faster than the Nation during the same period. Population growth was especially rapid in the Tampa-St. Petersburg subarea (38.4 percent). In 1969, the study

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[1] The study area is comprised of three BEA economic areas: 042, Orlando-Melbourne-Daytona Beach; 043, Miami-Fort Lauderdale; and 044, Tampa-St. Petersburg.

Table 6.1.--Population, Personal Income, Earnings, and Employment, 1969, 1978, and Projected 1985-2000

St. Lucie Study Area

	1969	1978	1985*	1990*	2000*
Population, July 1 (thousands)	5,043	6,692	8,041	8,806	10,092
		(millions of 1972 dollars)			
Total personal income (place of residence)	20,683	35,430	51,592	64,517	92,875
Earnings (place of work)	14,795	22,900	32,009	39,435	55,869
Farm	571	775	840	940	1,142
Nonfarm	14,224	22,124	31,169	38,494	54,726
Private	12,125	18,686	26,764	33,246	47,625
Agricultural services, forestry, fisheries, and other	130	237	326	391	530
Mining	55	90	112	126	157
Construction	1,411	1,709	2,464	2,984	4,094
Manufacturing	2,256	3,132	4,385	5,402	7,703
Nondurable goods	770	1,176	1,569	1,893	2,556
Durable goods	1,486	1,956	2,816	3,509	5,147
Transportation, communication, and utilities	1,204	2,074	2,934	3,635	5,135
Wholesale trade	907	1,529	2,156	2,621	3,647
Retail trade	2,075	3,101	4,314	5,258	7,442
Finance, insurance, and real estate	1,017	1,722	2,512	3,159	4,607
Services	3,069	5,092	7,561	9,668	14,312
Government	2,099	3,439	4,404	5,249	7,101
Federal civilian	426	617	797	942	1,257
Federal military	303	341	396	444	542
State and local	1,370	2,481	3,211	3,863	5,302
		(thousands of jobs)			
Total employment (place of work)	2,000	2,967	3,594	3,945	4,509
Farm	58	65	61	62	63
Nonfarm	1,942	2,902	3,533	3,883	4,447
Private	1,631	2,458	3,040	3,361	3,878
Agricultural services, forestry, fisheries, and other	27	54	65	70	78
Mining	6	8	8	8	8
Construction	156	208	265	279	297
Manufacturing	260	344	412	451	519
Nondurable goods	107	147	170	184	204
Durable goods	153	197	241	268	315
Transportation, communication, and utilities	120	164	192	206	227
Wholesale trade	97	153	186	203	229
Retail trade	368	582	713	792	929
Finance, insurance, and real estate	111	202	273	309	366
Services	486	742	926	1,042	1,225
Government	311	444	493	522	569
Federal civilian	44	50	55	57	62
Federal military	61	58	58	58	58
State and local	206	336	380	407	449

*Projected years are from OBERS Scenario II.

NOTE: Details may not add to totals because of rounding.

Table 6.2.--Percent Change in Population, Personal Income, Earnings, and Employment, Selected Years, 1969-2000

St. Lucie Study Area

	1969-78		1978-85*		1985-2000*	
	Percent change	Relative to U.S.	Percent change	Relative to U.S.	Percent change	Relative to U.S.
Population, July 1	32.70	393.03	20.15	307.16	25.52	215.54
Total personal income (place of residence)	71.30	1.95	45.62	1.48	80.02	1.41
Earnings (place of work)	54.78	1.86	39.78	1.27	74.54	1.32
Farm	35.79	2.84	8.35	.96	35.97	1.48
Nonfarm	55.54	1.86	40.88	1.28	75.58	1.32
Private	54.11	1.80	43.23	1.27	77.94	1.32
Agricultural services, forestry, fisheries, and other	81.64	1.49	37.77	1.18	62.53	1.17
Mining	63.26	.63	23.63	.48	40.78	.84
Construction	21.17	.92	44.15	1.35	66.15	1.15
Manufacturing	38.80	2.15	40.01	1.35	75.67	1.44
Nondurable goods	52.69	3.90	33.47	1.39	62.89	1.32
Durable goods	31.60	1.53	43.95	1.35	82.79	1.51
Transportation, communication, and utilities	72.22	1.80	41.46	1.26	74.99	1.25
Wholesale trade	68.57	1.65	41.03	1.31	69.12	1.38
Retail trade	49.43	2.38	39.14	1.32	72.50	1.38
Finance, insurance, and real estate	69.26	1.76	45.89	1.17	83.40	1.28
Services	65.93	1.49	48.49	1.14	89.28	1.19
Government	63.83	2.18	28.07	1.28	61.23	1.28
Federal civilian	44.91	2.08	29.12	1.34	57.73	1.32
Federal military	12.42	-.84	16.17	1.00	36.87	1.00
State and local	81.10	1.90	29.45	1.29	65.10	1.29
Total employment (place of work)	48.38	2.63	21.14	1.54	25.48	1.83
Farm	11.93	-1.55	-5.91	.71	3.00	-.29
Nonfarm	49.46	2.56	21.74	1.52	25.87	1.79
Private	50.72	2.46	23.67	1.48	27.59	1.74
Agricultural services, forestry, fisheries, and other	99.55	1.77	20.44	1.40	19.55	1.33
Mining	38.15	.93	.62	.03	-1.54	-.99
Construction	33.45	1.35	27.26	1.65	12.04	1.07
Manufacturing	32.46	18.34	19.58	1.86	26.01	2.70
Nondurable goods	38.12	-105.89	15.59	2.34	19.71	2.67
Durable goods	28.51	8.77	22.57	1.72	30.46	2.75
Transportation, communication, and utilities	37.07	3.34	16.75	1.65	18.51	1.83
Wholesale trade	57.44	1.77	21.84	1.38	22.98	1.88
Retail trade	58.24	2.09	22.49	1.39	30.29	1.80
Finance, insurance, and real estate	81.75	2.39	35.32	1.47	34.09	1.67
Services	52.72	1.59	24.71	1.21	32.37	1.37
Government	42.87	3.08	11.07	1.59	15.28	1.95
Federal civilian	14.09	-22.73	9.29	2.57	12.88	3.26
Federal military	-4.37	.15	-.38	1.00	.00	1.00
State and local	63.00	1.93	13.33	1.47	17.96	1.81

*Projected years are from OBERS Scenario II.

NOTE: Percent changes and relatives are calculated from rounded data.

area's per capita income was $4,101, 99 percent of the U.S. per capita income.[2] In 1978, it was $5,294, 1 percent more than nationally.

Total earnings from 1969 to 1978 increased 54.8 percent in the study area, 86 percent more than the Nation. In 1978, earnings amounted to $22.9 billion, representing almost 80 percent of Florida's total earnings. The Miami-Fort Lauderdale subarea accounted for one-half of the study area's total earnings.

Among the study area's various industries, earnings in agriculture, forestry, and fisheries registered the largest 1978 location quotient (LQ)--2.51--reflecting the area's citrus fruit industry and the large number of migrant agricultural workers employed there (table 6.3).[3] The LQ's in the Orlando-Melbourne-Daytona Beach and Tampa-St. Petersburg subareas were especially large, registering 3.12 and 3.20, respectively. Nevertheless, agriculture and farming (with an LQ of 1.35) accounted for only a combined 4.4 percent of the study area's total 1978 earnings.

The service-type industries accounted for the major share of the study area's total earnings in 1978--59 pecent--and their LQ's ranged from 1.32 (services) to 1.19 (transportation-communication-utilities), and 1.02 (wholesale trade). Services alone accounted for 22.2 percent of total 1978 earnings in the area, and retail trade, for 13.5 percent. Services and retail trade were strong in all three economic subareas. The relative importance of the service-type industries reflects the concentration of tourism and recreation in South Florida, the large number of retired persons residing there, and the growing importance of Miami as a banking center. Related to these

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2. All per capita income and earnings are expressed in 1972 dollars.

3. An earnings (or employment) LQ is the percent of total area earnings (or employment) originating in an industry divided by the percent of national earnings (or employment) originating in the same industry.

Table 6.3.--Earnings and Employment, Percent Distributions, and Location Quotients, 1969, 1978, and Projected 1985-2000

St. Lucie Study Area

	1969		1978		1985*		1990*		2000*	
	Percent distribution	LQ	Percent distribution	LQ	Percent distribution	LQ	Percent distribution	LQ	Percent distribution	LQ
Earnings (place of work)	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00
Farm	3.86	1.34	3.39	1.35	2.62	1.26	2.38	1.27	2.04	1.24
Nonfarm	96.14	.99	96.61	.99	97.38	.99	97.62	.99	97.96	1.00
Private	81.95	1.02	81.60	1.01	83.62	1.01	84.31	1.01	85.25	1.02
Agricultural services, forestry, fisheries, and other	.88	2.51	1.03	2.51	1.02	2.43	.99	2.41	.95	2.32
Mining	.37	.37	.39	.25	.35	.20	.32	.18	.28	.17
Construction	9.53	1.50	7.46	1.23	7.70	1.26	7.57	1.24	7.33	1.19
Manufacturing	15.25	.53	13.68	.52	13.70	.53	13.70	.53	13.79	.55
Nondurable goods	5.20	.49	5.13	.56	4.90	.56	4.80	.56	4.57	.56
Durable goods	10.05	.55	8.54	.50	8.80	.51	8.90	.52	9.21	.54
Transportation, communication, and utilities	8.14	1.15	9.06	1.19	9.17	1.19	9.22	1.18	9.19	1.17
Wholesale trade	6.13	1.02	6.68	1.02	6.74	1.03	6.65	1.03	6.53	1.04
Retail trade	14.02	1.31	13.54	1.36	13.48	1.37	13.33	1.37	13.32	1.39
Finance, insurance, and real estate	6.88	1.28	7.52	1.30	7.85	1.28	8.01	1.28	8.25	1.28
Services	20.74	1.37	22.24	1.32	23.62	1.29	24.52	1.28	25.62	1.26
Government	14.19	.86	15.02	.91	13.76	.90	13.31	.90	12.71	.88
Federal civilian	2.88	.68	2.69	.67	2.49	.67	2.39	.67	2.25	.66
Federal military	2.05	.90	1.49	.99	1.24	.93	1.13	.90	.97	.84
State and local	9.26	.93	10.83	.99	10.03	.98	9.79	.98	9.49	.97
Total employment (place of work)	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00
Farm	2.88	.82	2.18	.80	1.69	.77	1.56	.79	1.39	.80
Nonfarm	97.12	1.01	97.82	1.01	98.31	1.01	98.44	1.00	98.61	1.00
Private	81.57	1.05	82.85	1.04	84.58	1.04	85.20	1.04	86.00	1.04
Agricultural services, forestry, fisheries, and other	1.35	2.76	1.82	2.80	1.81	2.74	1.77	2.68	1.72	2.61
Mining	.29	.39	.27	.30	.22	.23	.20	.22	.18	.21
Construction	7.81	1.54	7.03	1.32	7.38	1.35	7.08	1.31	6.59	1.24
Manufacturing	13.00	.54	11.60	.56	11.45	.57	11.44	.58	11.50	.59
Nondurable goods	5.34	.54	4.97	.60	4.74	.61	4.66	.61	4.52	.62
Durable goods	7.66	.54	6.63	.54	6.71	.54	6.78	.56	6.98	.58
Transportation, communication, and utilities	5.99	1.10	5.54	1.09	5.34	1.08	5.22	1.07	5.04	1.05
Wholesale trade	4.86	1.05	5.15	.99	5.18	.98	5.14	.98	5.08	.98
Retail trade	18.40	1.24	19.63	1.23	19.84	1.21	20.09	1.21	20.61	1.23
Finance, insurance, and real estate	5.55	1.23	6.80	1.33	7.59	1.36	7.83	1.36	8.11	1.37
Services	24.31	1.34	25.02	1.23	25.76	1.19	26.42	1.18	27.17	1.16
Government	15.55	.84	14.97	.84	13.73	.82	13.24	.81	12.61	.79
Federal civilian	2.19	.65	1.69	.59	1.52	.58	1.45	.58	1.37	.58
Federal military	3.05	.79	1.97	.85	1.62	.79	1.47	.77	1.29	.72
State and local	10.30	.91	11.31	.89	10.59	.87	10.31	.86	9.95	.84

*Projected years are from OBERS Scenario II.

NOTE: Percent distributions calculated from rounded data.

phenomena is the construction industry, which in 1978 accounted for 7.5 percent of the region's total earnings and registered an LQ of 1.23. Construction was strongest in the Tampa-St. Petersburg subarea, where the LQ was 1.46 in 1978.

Although manufacturing accounted for over 13 percent of the study area's total earnings in 1978 (as it did throughout all of Florida), its LQ was only .52 (identical to Florida's), thus indicating that the area (and the State) is an importer of manufactured goods.

In 1978, government earnings accounted for 15.0 percent of the study area's total earnings, and its earnings LQ stood at .91, due to an earnings LQ of only .67 in the area's Federal civilian government earnings. In the Orlando-Melbourne-Daytona Beach subarea, the 1978 earnings LQ for the Federal military was 2.60, raising the study area's government LQ to .99. Subarea earnings LQ's for State and local government ranged from 1.05 in Tampa-St. Petersburg to .93 in Orlando-Melbourne-Daytona Beach.

Projected population and earnings, 1978-2000

The population of the study area is projected to increase to 8.0 million in 1985, and to 10.1 million in 2000, when it will account for 80 percent of the State's total population. This represents a population increase of 20.2 percent from 1978 to 1985 (three times the national rate), and an additional increase of 25.5 percent from 1985 to 2000 (over two times the national rate). The State's total population is projected to increase at between 1 and 2 percentage points less than that of the study area during the projection periods. The population of the Tampa-St. Petersburg subarea is projected to increase slightly faster than those of the other two economic subareas--22.4 percent from 1978 to 1985 and 26.3 percent from 1985 to 2000.

In 1985, the study area's per capita income is projected to be $6,416, almost the same as nationally. In 2000, it is projected to be $9,203, 3 percent more than nationally.

Total earnings in the study area are projected to increase 45.6 percent from 1978 to 1985, and an additional 80.0 percent from 1985 to 2000, both considerably above corresponding national rates of growth. Projected earnings will be $51.6 billion in 1985 and $92.9 billion in 2000. Earnings are projected to increase somewhat faster from 1978 to 1985 in the Tampa-St. Petersburg subarea, and from 1985 to 2000, at about the same rate in all three economic subareas.

The study area's agriculture, forestry, and fisheries are projected to register slightly diminishing LQ's--2.43 in 1985 and 2.32 in 2000. As in the past, the Orlando-Melbourne-Daytona Beach and Tampa-St. Petersburg subareas will have especially high LQ's of about 3.0 in future years, and agriculture and farming will account for only small percentages of total earnings--3.6 percent in 1985 and 3.0 percent in 2000.

The service-type industries are projected to account for a slightly increasing share of the study area's total earnings--60.9 percent in 1985 and 62.9 percent in 2000. Services alone will increase its share of the study area's total earnings from 22.2 percent in 1978 to 25.6 percent in 2000. Services in the Orlando-Melbourne-Daytona Beach subarea is projected to increase its share of subarea total earnings the most--4.7 percentage points--to 27.1 percent. While the earnings LQ's for most of the study area's service-type industries are projected to remain close to 1978 figures, the earnings LQ for services alone will decline from 1.32 in 1978 to 1.26 in 2000. For the study area as a whole, earnings LQ's in 2000 will range from 1.39 in retail trade and

1.28 in finance-insurance-real estate, to 1.04 in wholesale trade. Construction earnings will remain stable in the study area as a percent of total earnings--about 7.5 percent. Construction earnings in the Tampa-St. Petersburg subarea, however, are projected to increase to 9.3 percent of the total subarea earnings in 2000; earnings between 1978 and 1985 will increase 53.7 percent, with an LQ of 1.64, the highest LQ in all three economic subareas, and between 1978 and 2000, they will increase 71.2 percent, with an LQ of 1.24, again the highest rating among the three subareas.

Manufacturing earnings in the three economic subareas are projected to remain constant as a percent of total subarea earnings, with projected earnings LQ's in 2000 ranging from .62 to .53. Durables manufacturing earnings will remain strong in the study area as a whole, with a heavy emphasis in durables earnings continuing in the Orlando-Melbourne-Daytona Beach subarea and appearing in the Miami-Fort Lauderdale subarea by 2000. Manufacturing earnings are projected to increase 40 percent from 1978 to 1985 and 75.7 percent from 1985 to 2000, with growth apparent in all three economic subareas. Earnings growth, in relation to the Nation's performance, will be strongest in the Orlando-Melbourne-Daytona Beach subarea where manufacturing earnings increased at less than three-fourths of the Nation's growth rate from 1969 to 1978 and are projected to increase at almost one-and-one-half times the Nation's rate from 1985 to 2000, as they are in the other two economic subareas.

Government earnings in the study area are projected to increase 28.1 percent from 1978 to 1985 and 61.2 percent from 1985 to 2000; these rates are considerably above those for the Nation. Area earnings increases will be strongest at the State and local government level--29.5 percent from 1978 to 1985 and 65.1 percent from 1985 to 2000--and at the Federal civilian level--57.7

percent from 1985 to 2000. The three economic subareas are projected to closely follow the study area's performance, with the exception of Federal civilian earnings from 1978 to 1985 in the Tampa-St Petersburg subarea, which will increase much more (39.3 percent) than in either the Miami-Fort Lauderdale subarea (29.3 percent) or the Orlando-Melbourne-Daytona Beach subarea (17.7 percent).

Employment, 1969-78

Total employment in the study area increased 48.4 percent from 1969 to 1978, over 4 percentage points more than throughout Florida and over two-and-one-half times the national rate of increase. In 1978, total employment stood at 3.0 million in the area (78 percent of Florida's total employment), of which 1.4 million was accounted for by the Miami-Fort Lauderdale subarea.

The study area's largest employer was the services industry, with 742,000 employees in 1978, up 52.7 percent since 1969, over one-and-one-half times the national percent increase. Services employment increased fastest, 68.7 percent, in the Tampa-St. Petersburg subarea. Other area private industries with large employment in 1978 were retail trade (582,000), up 58.2 percent since 1969, over twice the U.S. rate of increase; manufacturing (344,000), up 32.5 percent, over eight times the U.S. rate of increase; and construction (208,000), up 33.5 percent, one-third more than nationally. Area government employment stood at 444,000 in 1978, with 336,000 employed at the State and local government level, of which almost one-half were found in the Miami-Fort Lauderdale subarea. While total area government employment increased 42.9 percent from 1969 to 1978 (three times more than nationally), employment at the State and local government level increased 63.0 percent (almost twice the national rate of increase).

Projected employment, 1978-2000

Total employment in the study area is projected to increase 21.1 percent from 1978 to 1985 and 25.5 percent from 1985 to 2000, somewhat more than in the State as a whole. Compared with the Nation, the study area's percent increases in total employment will be 54 percent from 1978 to 1985 and 83 percent from 1985 to 2000. Employment is projected to increase slightly faster in the Tampa-St. Petersburg subarea than in either of the other two economic subareas. Employment for the study area is projected to be 3.6 million in 1985 and 4.5 million in 2000, increases of .6 million and 1.5 million over the 1978 level.

Services are projected to remain the study area's largest employer; in 2000, services will account for 27.2 percent of the area's total employment, up from 25.0 percent in 1978. In the 1978-85 period, services employment in the area will increase almost 25 percent, 21 percent faster than nationally, and from 1985 to 2000, it will increase 32.4 percent, 37 percent faster than nationally. The percent increases will be greatest in the Orlando-Melbourne-Daytona Beach subarea (29 percent from 1978 to 1985 and 35 percent from 1985 to 2000), where services employment will account for 29.7 percent of the subarea's total employment in 2000, up from 26.1 percent in 1978.

Retail trade is projected to acccunt for 20.6 percent of the area's total employment in 2000, almost 25 percent more than the national share; this percent is the same as in 1978. Retail trade employment is projected to increase 22.5 percent from 1978 to 1985 and 30.3 percent from 1985 to 2000, at two-fifths and over three-fourths more, respectively, than national rates of increase.

Manufacturing employment will account for 11.5 percent of the area's total employment in 2000, about the same as in 1978; in both years, manufacturing's share of total area employment is less than two-thirds the national share.

Nonetheless, the projected area manufacturing employment increase of 19.6 percent from 1978 to 1985 will be 86 percent more than the Nation's percent increase, and the increase of 26.0 percent from 1985 to 2000 will be 17.0 percent more.

Employment in construction, projected to be 6.6 percent of the area's total employment in 2000, will be down slightly from 1978 as a share of the total; during the same period, the area's construction employment LQ is projected to decline from 1.32 in 1978 to 1.24 in 2000. In the Tampa-St. Petersburg subarea, however, unlike the other two economic subareas, construction employment will remain high, standing at 8.3 percent of total area employment in 2000, and the subarea's construction employment LQ will be 1.55. Construction is projected to be relatively weak in the Miami-Fort Lauderdale subarea, where employment will increase 18.9 percent from 1978 to 1985 (compared with 27.3 percent in the study area) and only 8.3 percent from 1985 to 2000 (compared with 12.0 percent), about one-fourth less than nationally.

Total government employment and State and local government employment, at 12.6 and 10.0 percent, respectively, of the area's total employment in 2000, will be down somewhat from 1978. Nevertheless, regional government employment is projected to increase 11.1 percent from 1978 to 1985 (59 percent more than nationally) and 15.3 percent from 1985 to 2000 (almost twice the national percent increase). Similarly, State and local government employment in the study area is projected to increase 13.3 percent from 1978 to 1985 (47 percent more than nationally), and 18.0 percent from 1981 to 2000 (81 percent more than nationally). Employment growth will be greatest in the Tampa-St. Petersburg subarea at both the total government and State and local government levels.

Impacts: SST1 Towards WNW

The industrial impact model was run for a reactor accident scenario (SST1[4/]) for a west-northwest (WNW) wind vector. Table 6.4 shows both the counties affected by the accident and the differing types of effects in these counties. For this hypothetical accident, table 6.5 shows the large directly affected agricultural and manufacturing industries; output data are estimated by RIMS II. (Nonagricultural output in the decontamination counties is lost for 3 months, so that if the decontamination counties accounted for 4 percent of U.S. output in a particular industry, this would appear as 1 percent in the table.) Total employment and selected industry-specific employment in each county of the interdicted and decontamination area are shown in table 6.6; actual levels (rather than one-quarter shares of annual totals for the decontamination area) are for 1978. Table 6.5 indicates that major economic effects would occur in the production of fruit (part of SIC 01), namely oranges and grapefruit. Table 6.6 indicates that an overwhelming part of the total direct manufacturing effects would take place in the interdicted counties, and that only a small percentage[5/] of the direct impacts could be mitigated by a "clean up" undertaken in the decontamination part of the physically affected area. Therefore, most of the direct impacts should be expected to persist after the first three months following the accident and even beyond the first year.

Table 6.7 shows the effects of the accident on aggregated industry-specific employment, both in the physically affected area and in the physically

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4. SST1 is the designation given by NRC to a "worst-case" severe accident scenario in which all safety systems fail. The characteristics of this type of accident for private-sector industrial activity are shown in table 6.4; for additional details on SST1 accidents (and other types of accidents), see Pasedag, et al. (1981).

5. For the interdicted and decontamination areas combined, the interdicted area represents 77 percent of BEA total employment.

Table 6.4.--Production Loss, by County, St. Lucie Nuclear Reactor, SST1-WNW (22.5° arc)

Type of production loss	Counties	Length of production loss	Extent of tourist avoidance
Physical contamination: All industries	Physically affected: Interdicted (27 miles) Indian River, FL St. Lucie, FL (host county) Martin, FL	More than 1 year, all industries including agricultural production	100% for more than 1 year
All industries, except agriculture	Decontamination (86 miles) Okeechobee, FL Highlands, FL	Three months loss in nonagricultural output; one year loss in all crop output, except no loss in greenhouse, nursery, and forestry output; three months loss in dairy output; and six months loss in livestock and poultry output	100% for 3 months, then 75% for 9 months
Agriculture, including dairy milk	Crop-interdicted (199 miles) All of the above, and Hernando, FL Pasco, FL Hillsborough, FL Hardee, FL Polk, FL No further contamination; the Gulf of Mexico is 160 miles from the reactor site.	No loss in nonagricultural output; one year loss in agricultural output, except no loss in greenhouse, nursery, and forestry output; no loss in livestock and poultry output; and two months loss in dairy output	45% for 1 year; except in the interdicted and contaminated areas as noted above
Indirect economic effects:	Physically unaffected: BEA Economic Areas* 42-44, less above counties	First year only, based on RIMS II	10% for 1 year

*For component counties, see BEA Economic Areas (Revised 1977), BEA, U.S. Department of Commerce, Washington, D.C.

Table 6.5.--Large Direct Effects in Agriculture and Manufacturing Due to an SST1-WNW, St. Lucie Nuclear Reactor

Industry name	SIC code	Percent range of U.S. output
Fruits	part of 01	25-30
Vegetables	part of 01	1-5
Dairy farm products	part of 02	1-5
Agricultural services	07	1-5
Canned fruits and vegetables	2033	1-5 I
Frozen fruits and vegetables	2037-8	1-5 I
Fertilizers, mixing only	2875	1-5 I
Aircraft and aircraft engines	3721, 3724	1-5 I

I indicates that effects occur primarily in the interdicted area.

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Table 6.6.--Large Direct Effects on Manufacturing Employment (1978) Due to an SST1-WNW, by County, St. Lucie Nuclear Reactor

SIC code	Industry name	Number of employees affected for more than one year			Number of employees affected for three months	
		St. Lucie, FL	Indian River, FL	Martin, FL	Okeechobee, FL	Highlands, FL
07	Agriculture services	F	G	F	*	E
203	Canned and preserved fruits and vegetables	F	*	B	*	*
287	Agricultural chemicals	E	*	*	*	*
372	Aircraft and aircraft engines and parts	*	H	F	*	B
---	Total manufacturing, CBP	2,321	3,753	1,823	187	736
---	Total private sector, CBP	16,998	16,865	13,724	2,301	7,466
---	Total manufacturing, BEA	1,557	3,524	1,944	178	674
---	Total private, BEA	22,828	20,195	19,774	5,086	11,997
---	Total all sectors, BEA	27,495	23,183	21,893	6,466	14,940

*Industry not present in the county.

Range of employment effect--B:20-99; E:250-499; F:500-999; G:1,000-2,499; H:2,500-4,999.

Source: U.S. Department of Commerce, Bureau of the Census, County Business Patterns (CBP), 1978, Wasington, D.C., 1981.

Table 6.7.--Private-Sector Employment Losses (1978) Due to an SST1-WNW, St. Lucie Nuclear Reactor

(Thousands of annual jobs)

Industry	Total employment		Direct losses in the physically affected area	Indirect losses in the physically unaffected area due to		
	U.S.	Study area		Decreased exports	Tourist avoidance	Supply constraints
Agriculture	3,417	119	35	0	0	
Mining	901	8	0	0	0	
Construction	5,387	208	4	2	0	
Nondurables manufacturing	8,377	147	2	1	0	30*
Durables manufacturing	12,519	197	4	0	0	
Transportation, communication, and utilities	5,159	164	3	0	0	
Wholesale trade	5,248	153	2	1	0	
Retail trade	16,198	582	14	0	4	
Finance, insurance, and real estate	5,190	202	4	0	0	
Services	20,630	742	12	0	3	
Total	**83,026**	**2,522**	**80**	**4**	**7**	

*Up to 30,000 annual jobs in the food and kindred products industry (a part of nondurables manufacturing) in the study area are vulnerable to the decreased availability of agricultural inputs.

unaffected area. Economic effects in the physically unaffected area could occur because of (1) decreased exports to (demand by) the physically affected area, (2) tourist avoidance, and (3) decreased imports from (supply by) the physically affected area. (These effects are on an annual basis for 1978; therefore, a job lost in the decontamination area is counted as one-quarter of a job). Major direct effects would occur in agriculture (mostly fruits and vegetables), retail trade, and services, the last two industries directly related to the study area's heavy reliance on the retirement community and tourist activities. Indirect effects are considerably smaller. Tourist-related effects in the unaffected area take place in retail trade (where the direct effects on eating and drinking establishments are the largest part) and services (where the direct effects on hotel and lodging places are the largest part).

Only one industry in the physically unaffected area, nondurable goods manufacturing (of canned and processed fruits and vegetables), is vulnerable to a supply constraint. (The employment effect is on an annual basis.) The constraint is estimated after first permitting output to increase up to maximum desired capacity in the physically unaffected area, and the employment loss would occur in this industry if it was impossible to import, from elsewhere in the United States, required inputs no longer available from the physically affected area. Since fruits and vegetables from elsewhere in the United States could be forthcoming only with great difficulty, the linkage of the constraining industry with the vulnerable industry is likely to result in lost employment.

Table 6.8 shows employment (annual basis) losses when two compensating effects have taken place. If output increased up to maximum desired capacity in the physically unaffected area, but households had not yet resumed their normal consumption, then job losses in nondurables manufacturing would be halved.

Table 6.8.--Private-Sector Employment Losses (1978) Due to an SST1-WNW, St. Lucie Nuclear Reactor

(Thousands of annual jobs)

Industry	Direct losses[1]	Partially compensated losses[2]	Fully compensated losses[3]
Agriculture	35	35	35
Mining	0	0	0
Construction	4	3	2
Nondurables manufacturing	2	1	0
Durables manufacturing	4	3	3
Transportation, communication, and utilities	3	2	1
Wholesale trade	2	2	1
Retail trade	14	13	1
Finance, insurance, and real estate	4	0	0
Services	12	10	2
Total	**80**	**69**	**45**

1. Direct losses in the physically affected area; see column 3, table 6.7.

2. Partially compensated losses would occur, if output increases up to the maximum desired capacity in the physically unaffected area, but households do not resume normal consumption.

3. Fully compensated losses would occur, if output increases up to maximum desired capacity in the physically unaffected area, and households resume normal consumption.

However, losses in retail trade and services would decrease only slightly since these industries are affected primarily by household expenditures. If household expenditures attained their former level, total job losses would decrease considerably. Only agriculture, which is assumed to be unable to expand capacity in the one-year impact interval adopted in this monograph, shows the same job loss as in the initial case. However, it is important to recognize that the difference between the initial case and the fully compensated case is itself a measure of the size of the adjustment that must occur in the physically unaffected area. Considerable time may be required for the physically unaffected area to assimulate all but 45,000 of the initial 80,000 annual jobs directly affected.

Chapter 7

PERRY NUCLEAR REACTOR

The industrial impact model used to estimate the private-sector effects of a hypothetical accident at the Perry nuclear reactor indicates that the total employment losses in all industries directly affected by the accident could be 288,000 (5.3 percent of the total employment in the economic area surrounding the Perry reactor site). In addition to large direct effects in local service-type industries, major impacts could occur in both durable goods and nondurable goods manufacturing. Moreover, impacts associated with a decrease in tourist activity could total an additional 27,000 annual jobs, primarily in eating and drinking places, and in hotels and other lodging places. Finally, the model indicates that more than 20,000 annual jobs in the contract construction, nonelectrical machinery, and motor vehicles are vulnerable to the decreased availability of electrical machinery inputs.

Economic Profile

Population and earnings, 1969-78

On July 1, 1978, the population of the study area[1] was 13.9 million, up 2.4 percent since July 1, 1969 (tables 7.1 and 7.2). Concurrently, the population of the United States increased three-and-one-half times faster. In 1969, the study area's per capita income was $4,250, 103 percent of the U.S. per capita income.[2] In 1978, it was $5,220, almost the same as nationally.

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[1] The study area consists primarily of the State of Ohio, plus four adjacent BEA economic areas located in Indiana: 075, South Bend; 077, Kokomo-Marion; 078, Anderson-Muncie; and 079, Indianapolis. Ohio accounts for nearly four-fifths of the total population of the study area.

[2] All per capita income and earnings are expressed in 1972 dollars.

Table 7.1.--Population, Personal Income, Earnings, and Employment, 1969, 1978, and Projected 1985-2000

Perry Study Area

	1969	1978	1985*	1990*	2000*
Population, July 1 (thousands)	13,572	13,892	14,350	14,732	15,204
(millions of 1972 dollars)					
Total personal income (place of residence)	57,693	72,520	93,308	109,021	139,120
Earnings (place of work)	48,658	58,013	75,272	88,043	112,799
Farm	854	808	1,014	1,108	1,340
Nonfarm	47,804	57,205	74,258	86,935	111,459
Private	42,240	50,228	65,756	77,173	99,176
Agricultural services, forestry, fisheries, and other	105	131	164	188	230
Mining	254	498	852	1,045	1,326
Construction	3,240	3,035	3,933	4,578	5,859
Manufacturing	20,167	23,129	29,286	33,764	42,221
Nondurable goods	5,106	5,586	6,852	7,825	9,622
Durable goods	15,061	17,542	22,433	25,939	32,599
Transportation, communication, and utilities	3,094	4,042	5,289	6,271	8,247
Wholesale trade	2,515	3,361	4,344	4,998	6,277
Retail trade	4,971	5,530	7,047	8,119	10,165
Finance, insurance, and real estate	2,035	2,513	3,502	4,220	5,658
Services	5,859	7,989	11,340	13,989	19,193
Government	5,564	6,977	8,502	9,762	12,283
Federal civilian	1,386	1,492	1,776	1,986	2,417
Federal military	323	246	286	321	392
State and local	3,855	5,238	6,440	7,454	9,474
(thousands of jobs)					
Total employment (place of work)	5,786	6,355	7,089	7,396	7,671
Farm	118	120	112	109	106
Nonfarm	5,669	6,235	6,977	7,288	7,565
Private	4,840	5,299	5,987	6,279	6,545
Agricultural services, forestry, fisheries, and other	17	22	24	25	25
Mining	23	33	46	49	48
Construction	294	297	340	351	364
Manufacturing	1,943	1,845	1,987	2,031	2,043
Nondurable goods	531	509	537	546	548
Durable goods	1,412	1,337	1,450	1,485	1,496
Transportation, communication, and utilities	298	304	331	343	357
Wholesale trade	240	300	338	350	362
Retail trade	883	1,045	1,191	1,254	1,308
Finance, insurance, and real estate	227	279	341	366	393
Services	915	1,173	1,390	1,508	1,645
Government	828	935	990	1,009	1,020
Federal civilian	133	116	118	118	117
Federal military	91	66	65	65	65
State and local	604	753	806	826	837

*Projected years are from OBERS Scenario II.

NOTE: Details may not add to totals because of rounding.

Table 7.2.--Population, Personal Income, Earnings, and Employment, Percent Changes, Selected Years, 1969-2000

Perry Study Area

	1969-78		1978-85*		1985-2000*	
	Percent change	Relative to U.S.	Percent change	Relative to U.S.	Percent change	Relative to U.S.
Population, July 1	2.36	28.37	3.30	50.30	5.95	50.25
Total personal income (place of residence)	25.70	.70	28.66	.93	49.10	.87
Earnings (place of work)	19.23	.65	29.75	.95	49.85	.88
Farm	-5.42	-.43	25.48	2.92	32.12	1.32
Nonfarm	19.67	.66	29.81	.93	50.10	.87
Private	18.92	.64	30.91	.93	50.55	.87
Agricultural services, forestry, fisheries, and other	24.64	.45	24.81	.78	40.22	.75
Mining	95.92	.95	71.20	1.46	55.67	1.15
Construction	-6.32	-.28	29.60	.91	48.96	.85
Manufacturing	14.69	.81	26.62	.90	44.17	.84
Nondurable goods	9.41	.70	22.66	.94	40.42	.85
Durable goods	16.47	.80	27.88	.85	45.31	.83
Transportation, communication, and utilities	30.65	.76	30.84	.94	55.94	.94
Wholesale trade	33.67	.81	29.24	.94	44.50	.89
Retail trade	11.25	.54	27.42	.93	44.25	.84
Finance, insurance, and real estate	23.46	.60	39.36	1.00	61.56	.95
Services	36.34	.82	41.94	.99	69.26	.93
Government	25.40	.87	21.87	1.00	44.46	.93
Federal civilian	7.65	.35	18.99	.88	36.13	.83
Federal military	-23.63	1.61	16.17	1.00	36.87	1.00
State and local	35.89	.84	22.95	1.01	47.10	.93
Total employment (place of work)	9.83	.53	11.55	.84	8.21	.59
Farm	2.03	-.26	-6.44	.77	5.67	-.54
Nonfarm	9.99	.52	11.90	.83	8.43	.58
Private	9.49	.49	12.97	.86	9.33	.62
Agricultural services, forestry, fisheries, and other	29.19	.52	9.09	.62	5.18	.35
Mining	39.06	.95	39.62	1.87	6.12	3.92
Construction	.92	.04	14.34	.87	7.09	.63
Manufacturing	-5.03	-2.84	7.68	.73	2.84	.29
Nondurable goods	-4.15	11.53	5.56	.83	2.03	.27
Durable goods	-5.36	-1.65	8.48	.65	3.14	.28
Transportation, communication, and utilities	2.16	.19	8.67	.86	7.79	.77
Wholesale trade	25.13	.77	12.69	.80	7.04	.58
Retail trade	18.38	.66	13.99	.86	9.82	.58
Finance, insurance, and real estate	23.19	.68	21.99	.92	15.27	.75
Services	28.24	.85	18.42	.90	18.38	.78
Government	12.92	.93	5.83	.84	3.02	.39
Federal civilian	-12.55	20.24	1.39	.39	-.59	-.15
Federal military	-28.23	.99	-.39	1.03	.00	1.00
State and local	24.78	.76	7.06	.78	3.79	.39

*Projected years are from OBERS Scenario II.

NOTE: Percent changes and relatives are calculated from rounded data.

From 1969 to 1978, total earnings increased only 19.2 percent in the area, compared with 29.4 percent nationally. During the 9-year period, area earnings for all industries grew at less than national rates, with the exception of Federal military earnings, which increased 61 percent more than the Nation. In 1978, area earnings totaled $58.0 billion, or 6.6 percent of the U.S. total earnings.

Among the area's various industries in 1969, durable goods manufacturing registered the largest location quotient (LQ)--1.70--reflecting the export base in durable goods products (table 7.3).[3] In 1969, durable goods manufacturing accounted for 31.0 percent of the study area's total earnings. The LQ for nondurable goods manufacturing, which accounted for 10.5 percent of total earnings, was 1.00. The only other industry with an above-average share (relative to the Nation) was contruction, with an LQ of 1.05 and accounting for 6.7 percent of total area earnings. Retail trade, which accounted for 10.2 percent of total earnings, registered an LQ of .96, and services, at 12.0 percent of total earnings, registered an LQ of .80. Total government earnings accounted for 11.4 percent of total earnings, and State and local government earnings, for 7.9 percent; LQ's were .69 and .80, respectively.

In 1978, the same situation generally prevailed, with two major exceptions. Durables goods manufacturing earnings increased their LQ to 1.78, while maintaining a percent share of total earnings close to what it had been in 1969. Construction earnings, however, registered a decline to 5.2 percent with an LQ of .86; from 1969 to 1978, construction earnings increased by 6.3 percent, only one-fourth the national rate.

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[3] An earnings (or employment) LQ is the percent of total area earnings (or employment) originating in an industry divided by the percent of national earnings (or employment) originating in the same industry.

Table 7.3.--Earnings and Employment, Percent Distributions, and Location Quotients, 1969, 1978, and Projected 1985-2000

Perry Study Area

	1969		1978		1985*		1990*		2000*	
	Percent distribution	LQ	Percent distribution	LQ	Percent distribution	LQ	Percent distribution	LQ	Percent distribution	LQ
Earnings (place of work)	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00
Farm	1.76	.61	1.39	.55	1.35	.65	1.26	.67	1.19	.72
Nonfarm	98.24	1.01	98.61	1.01	98.65	1.01	98.74	1.01	98.81	1.00
Private	86.81	1.04	86.81	1.04	87.35	1.03	87.65	1.03	87.92	1.03
Agricultural services, forestry, fisheries, and other	.22	.63	.23	.56	.22	.52	.21	.51	.20	.49
Mining	.52	.52	.86	.55	1.13	.64	1.19	.67	1.18	.71
Construction	6.66	1.05	5.23	.86	5.23	.85	5.20	.85	5.19	.84
Manufacturing	41.45	1.44	39.87	1.52	38.91	1.50	38.35	1.50	37.43	1.49
Nondurable goods	10.49	1.00	9.63	1.04	9.10	1.04	8.89	1.04	8.53	1.04
Durable goods	30.95	1.70	30.24	1.78	29.80	1.74	29.46	1.72	28.90	1.70
Transportation, communication, and utilities	6.36	.90	6.97	.91	7.03	.91	7.12	.91	7.31	.93
Wholesale trade	5.17	.86	5.79	.88	5.77	.88	5.68	.88	5.57	.89
Retail trade	10.22	.96	9.53	.95	9.36	.95	9.22	.95	9.01	.94
Finance, insurance, and real estate	4.18	.78	4.33	.75	4.65	.76	4.79	.76	5.02	.78
Services	12.04	.80	13.77	.82	15.06	.83	15.89	.83	17.02	.84
Government	11.43	.69	12.03	.73	11.30	.74	11.09	.75	10.89	.76
Federal civilian	2.85	.67	2.57	.64	2.36	.64	2.26	.63	2.14	.63
Federal military	.66	.29	.42	.28	.38	.29	.36	.29	.35	.30
State and local	7.92	.80	9.03	.82	8.56	.84	8.47	.84	8.40	.85
Total employment (place of work)	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00
Farm	2.03	.58	1.89	.69	1.58	.72	1.47	.74	1.38	.80
Nonfarm	97.97	1.02	98.11	1.01	98.42	1.01	98.53	1.01	98.62	1.00
Private	83.65	1.03	83.39	1.02	84.46	1.02	84.89	1.02	85.33	1.02
Agricultural services, forestry, fisheries, and other	.30	.61	.35	.54	.34	.52	.34	.52	.33	.50
Mining	.41	.55	.51	.57	.64	.67	.66	.71	.63	.74
Construction	5.09	1.01	4.67	.88	4.79	.88	4.75	.88	4.74	.89
Manufacturing	33.58	1.40	29.04	1.41	28.03	1.40	27.46	1.39	26.64	1.38
Nondurable goods	9.17	.93	8.00	.97	7.57	.97	7.38	.97	7.14	.97
Durable goods	24.41	1.72	21.03	1.70	20.45	1.66	20.08	1.64	19.50	1.62
Transportation, communication, and utilities	5.15	.95	4.79	.94	4.67	.95	4.64	.95	4.65	.97
Wholesale trade	4.14	.89	4.72	.91	4.77	.90	4.74	.90	4.72	.91
Retail trade	15.26	1.03	16.45	1.03	16.81	1.03	16.96	1.02	17.06	1.02
Finance, insurance, and real estate	3.92	.87	4.40	.86	4.81	.86	4.94	.86	5.12	.86
Services	15.81	.87	18.47	.91	19.60	.91	20.39	.91	21.44	.91
Government	14.32	.77	14.72	.82	13.96	.83	13.64	.83	13.29	.83
Federal civilian	2.30	.68	1.83	.64	1.67	.64	1.60	.64	1.53	.65
Federal military	1.58	.41	1.03	.44	.92	.45	.88	.46	.85	.47
State and local	10.43	.92	11.85	.93	11.38	.93	11.16	.93	10.91	.93

*Projected years are from OBERS Scenario II.

NOTE: Percent distributions calculated from rounded data.

Projected population and earnings, 1978-2000

The population of the area is projected to increase to 14.4 million by 1985, and to 15.2 million by 2000. This represents a population increase of 3.3 percent from 1978 to 1985 and an additional increase of 6.0 percent from 1985 to 2000; during both periods the area's rates of population increases will be only one-half of the corresponding national increases.

In 1985, the study area's per capita income is projected to be $6,502, 1 percent more than nationally, and in 2000, it is projected to be $9,150, 2 percent more than nationally.

Total earnings in the study area are projected to increase 30.0 percent from 1978 to 1985, and an additional 49.9 percent from 1985 to 2000; these increases will be 93 percent and 87 percent of the corresponding national increases for the respective periods. Area earnings are projected to reach $75.3 billion in 1985 and $112.8 billion in 2000.

Earnings in durables goods manufacturing are projected to yield declining LQ's of 1.74 in 1985 and 1.70 in 2000, with earnings of nondurable goods yielding relatively constant LQ's of 1.04 in both years. These industries are the only ones projected to have LQ's of over .95 in both years. Earnings in durable goods manufacturing are projected to account for a greater share of total area earnings than any other industry--29.8 percent in 1985 and 28.9 in 2000. Services is projected to increase its share of total earnings from 13.8 percent in 1978 to 15.1 percent in 1985 and 17.0 percent in 2000, while at the same time maintaining an LQ in a range of .82 to .84. Most other industries are projected to largely maintain their current levels of both percent of total earnings and LQ.

Employment, 1969-78

Total employment in the area increased 9.8 percent from 1969 to 1978, little more than one-half the national rate. In 1978, area employment totaled 6.4 million.

In 1978, the area's largest employer was the durable goods manufacturing industry (1.3 million, or 21.0 percent of the total), followed by services (18.5 percent), retail trade (16.5 percent), and State and local government (11.9 percent). Only durable goods manufacturing and retail trade registered 1978 employment LQ's of over 1.00--1.70 and 1.03, respectively. Services registered an LQ of .91 and State and local government, an LQ of .93. The Federal military registered the smallest LQ--only .44.

In the 1969-78 period, employment in durable goods manufacturing increased 5.4 percent, almost one-and-two-thirds the national rate of increase. The only other industry in which employment increased at a greater rate than that experienced nationally during the 9-year period was nondurable goods manufacturing, up 4.2 percent, or one-and-one-half times the national rate. Services, retail trade, and State and local government, although increasing regional employment by 28.2, 18.4, and 24.8 percent, respectively, from 1969 to 1978, lagged corresponding nationwide rates of increase by 15 to 34 percent.

Projected employment, 1978-2000

Total employment in the area is projected to increase 11.6 percent from 1978 to 1985 (to 7.1 million) and an additional 8.2 percent from 1985 to 2000 (to 7.7 million). From 1978 to 1985, the area's employment rate of increase will be 84 percent of the national rate of increase, and from 1985 to 2000, it will be only 59 percent of the national rate. Of the largest employment groups, services employment is projected to undergo the greatest change, increasing its share of total employment to 19.6 percent in 1985 and 21.4 percent in 2000. At the same time, however, services employment LQ is projected to remain at the 1978 figure of .91. Employment in durable goods manufacturing is projected to decrease its share of total employment only slightly, to 19.5 percent in 2000, with a reduced LQ of 1.62. Retail trade will increase its share of total employment slightly to 17.1 percent and decrease its LQ fractionally to 1.02. State and local government employment will decrease its share of the total (to 10.9 percent in 2000) and largely maintain employment LQ's in the projected years.

Impacts: SST1 Towards SW

The industrial impact model was run for a reactor accident scenario (SST1) for a southwest (SW) wind vector. Table 7.4 shows both the counties affected by the accident and the differing types of effects in these counties. For this hypothetical accident, table 7.5 shows the large directly affected agricultural and manufacturing industries; output data are estimated by RIMS II. (Nonagricultural output in the decontamination counties is lost for 3 months, so that if the decontamination counties accounted for 4 percent of U.S. output in a particular industry, this would appear as 1 percent in the table.) Total employment and selected industry-specific employment in each county of the interdicted and decontamination areas are shown in table 7.6; actual levels (rather than one-quarter shares of annual totals for the decontamination area) are for 1978. Tables 7.5 and 7.6 indicate that major industrial effects would occur in machinery, fabricated metal products (except transportation equipment), and primary metal industries (SIC 33-36). Table 7.6 indicates that only a small part of the total direct industrial effects would take place in the

Table 7.4.--Production Loss, by County, Perry Nuclear Reactor, SST1-SW (22.5^{0} arc)

Type of production loss	Counties	Length of production loss	Extent of tourist avoidance
Physical contamination: All industries	Physically affected: Interdicted (21 miles) Lake, OH (host county) Geauga, OH Ashtabula, OH	More than 1 year, all industries including agricultural production	100% for more than 1 year
All industries, except agriculture	Decontamination (94 miles) Medina, OH Ashland, OH Cuyahoga, OH Wayne, OH	Three months loss in nonagricultural output; one year loss in all crop output, except no loss in greenhouse, nursery, and forestry output; three months loss in dairy output; and six months loss in livestock and poultry output	100% for 3 months, then 75% for 9 months
Agriculture, except dairy milk	Crop-interdicted (271 miles) All of the above, and Crawford, OH Richland, OH Morrow, OH Knox, OH Marion, OH Delaware, OH Licking, OH Union, OH	No loss in nonagricultural output; one year loss in agricultural output, except no loss in greenhouse, nursery, and forestry output; no loss in livestock and poultry output; and two months loss in dairy output	45% for 1 year; except in the interdicted and contaminated areas as noted above
Dairy milk only	Milk-interdicted (298 miles) All of the above, and Champaign, OH Miami, OH Clark, OH Montgomery, OH Preble, OH Butler, OH Franklin, OH Clermont, OH Brown, OH Adams, OH Highland, OH Clinton, OH Warren, OH Green, OH Fayette, OH Ross, OH Pickaway, OH Madison, OH Hamilton, OH Ripley, IN Dearborn, IN Switzerland, IN Franklin, IN Ohio, IN Galatin, KY Owen, KY Robertson, KY Fleming, KY Mason, KY Bracken, KY Pendleton, KY Grant, KY Boone, KY Keaton, KY Campbell, KY	No loss of output in any industrial sector, except two months loss in dairy output	45% for 1 year; except in the interdicted and contaminated areas as noted above
Indirect economic effects:	Physically unaffected: BEA Economic Areas* Ohio, plus 75 and 77-79, less above counties in Indiana and Kentucky	First year only, based on RIMS II	10% for 1 year

*For component counties, see BEA Economic Areas (Revised 1977), BEA, U.S. Department of Commerce, Washington, D.C.

Table 7.5.--Large Direct Effects in Agriculture and Manufacturing Due to an SST1-SW, Perry Nuclear Reactor

Industry name	SIC code	Percent range of U.S. output	
Food grains	part of 01	1-5	
Dairy farm products	part of 02	1-5	
Canvas products	2394	1-5	C
Household furniture, n.e.c.	2519	11-15	C
Metal partitions and fixtures	2542	1-5	C
Greeting card publishing	277	1-5	C
Bookbinding and related work	2789	1-5	C
Photoengraving	2793	1-5	C
Paints and allied products	285	6-10	C
Adhesives and sealants	2891	1-5	I/C
Printing ink	2893	1-5	C
Chemical preparations, n.e.c.	2899	6-10	I/C
Asphalt felts and coatings	2952	11-15	I
Fabricated rubber products, n.e.c.	306	6-10	I/C
Miscellaneous plastics products	307	1-5	I
Clay refractories	3255	1-5	C
Vitreous plumbing fixtures	3261	6-10	C
Fine earthenware food utensils	3263	6-10	C
Abrasive products	3291	1-5	C
Nonmetallic mineral products, n.e.c.	3299	11-15	I
Blast furnaces	3312	1-5	C
Electrometallurigal products	3313	1-5	I
Steel wire and related products	3315	1-5	I/C
Steel pipe and tubes	3317	1-5	C
Iron and steel foundries	332	1-5	C
Metal heat treating	3398	6-10	I/C
Primary metal products, n.e.c.	3399	6-10	C
Secondary nonferrous metals	334	1-5	C
Nonferrous rolling and drawing, n.e.c.	3356	11-15	I/C
Aluminum castings	3361	1-5	I/C
Brass, bronze, and copper castings	3362	1-5	C
Nonferrous castings, n.e.c.	3369	1-5	I
Metal barrels, drums, and pails	3412	1-5	I/C
Hand and edge tools, n.e.c.	3423	1-5	I
Plumbing fixture fittings and trim	3432	1-5	C
Heating equipment, except electric	3433	1-5	C
Miscellaneous metal work	3449	6-10	C
Screw machine products	345	6-10	I/C
Iron and steel forgings	3462	1-5	I/C
Nonferrous forgings	3463	21-25	C

Table 7.5.--Large Direct Effects in Agriculture and Manufacturing Due to an SST1-SW, Perry Nuclear Reactor--Continued

Industry name	SIC code	Percent range of U.S. output	
Automotive stampings	3465	11-15	C
Metal stampings, n.e.c.	3469	1-5	I/C
Plating and polishings	3471	1-5	C
Pipe, valves, and pipe fittings	3494, 3498	1-5	I/C
Miscellaneous fabricated wire products	3495-6	1-5	I/C
Fabricated metal products, n.e.c.	3499	1-5	I/C
Construction machinery and equipment	3531	1-5	C
Mining machinery, except oil field	3532	1-5	C
Hoists, cranes, and monorails	3536	6-10	I
Industrial trucks and tractors	3537	16-20	I
Machine tools, metal cutting types	3541	6-10	C
Machine tools, metal forming types	3542	6-10	C
Special dies and machine tool accessories	3544-5	1-5	I/C
Power-driven hand tools	3546	1-5	I/C
Rolling mill machinery	3547	1-5	I
Metal working machinery, n.e.c.	3549	1-5	C
Wood working machinery	3553	1-5	I
Special industry machinery, n.e.c.	3559	6-10	I/C
Industrial patterns	3565	1-5	I
Power transmission equipment	3566, 3568	1-5	I
General industrial machinery, n.e.c.	3569	1-5	I
Office machines, n.e.c.	3579	1-5	I
Carburetors, pistons, rings, valves	3592	1-5	I
Machinery, except electrical, n.e.c.	3599	1-5	I
Industrial controls	3622	1-5	I/C
Welding apparatus, electric	3623	31-35	C
Carbon and graphite products	3624	6-10	I
Electrical industrial apparatus, n.e.c.	3629	6-10	I/C
Electric housewares and fans	3634	6-10	C
Household vacuum cleaners	3635	11-15	C
Electric lamps	3641	6-10	C
Lighting fixtures and equipment	3645-8	1-5	C
Electrical equipment, n.e.c.	3699	6-10	I
Motor vehicle parts and accessories	3714	6-10	I/C
Aircraft and missle equipment, n.e.c.	3728, 3764	1-5	C
Mechanical measuring devices	3823-4, 3829	1-5	I
Musical instruments	393	1-5	I
Brooms and brushes	3991	11-15	I/C

I indicates that effects occur primarily in the interdicted area.
C indicates that effects occur primarily in the decontamination area.
I/C indicates that large effects occur in both areas.

Table 7.6.--Large Direct Effects on Manufacturing Employment (1978) Due to an SST1-SW, by County, Perry Nuclear Reactor

SIC code	Industry name	Number of employees affected for more than one year			Number of employees affected for three months			
		Lake, OH	Geauga, OH	Ashtabula, OH	Cuyahoga, OH	Medina, OH	Ashland, OH	Wayne, OH
239	Miscellaneous fabricated textile products	*	*	*	H	*	*	*
251	Household furniture	*	*	*	1,167	B	*	*
254	Partitions and fixtures	*	*	*	1,064	*	*	*
277	Greeting card publishing	*	*	*	F	*	*	*
278	Blankbooks and bookbinding	*	C	*	463	*	*	*
279	Printing trade services	*	*	*	522	*	*	*
285	Paints and allied products	187	*	*	2,257	E	*	*
289	Miscellaneous chemical products	223	*	B	1,699	139	B	E
295	Paving and roofing materials	62	*	*	1,019	B	*	B
306	Fabricated rubber products, n.e.c.	1,094	2,180	C	F	966	G	186
307	Miscellaneous plastics products	E	1,265	H	4,195	C	C	G
325	Structural clay products	*	*	*	E	C	*	*
326	Pottery and related products	*	*	*	C	*	F	B
329	Miscellaneous nonmetallic mineral products	129	*	C	1,369	217	*	E
331	Blast furnace and basic steel products	C	*	G	J	B	*	E
332	Iron and steel foundries	C	*	*	8,419	*	E	E
334	Secondary nonferrous metals	*	*	*	950	*	*	*
335	Nonferrous rolling and drawing	C	*	*	2,986	B	*	C
336	Nonferrous foundries	342	*	C	H	E	*	C
339	Miscellaneous primary metal products	171	*	*	1,643	*	*	*
341	Metal cans and shipping containers	*	*	B	F	*	*	*
342	Cutlery, hand tools, and hardware	F	*	F	1,211	*	*	B
343	Plumbing and heating, except electric	*	*	*	1,673	*	*	*
344	Fabricated structural metal products	E	*	G	5,210	357	*	B
345	Screw machine products, bolts, etc.	1,040	140	C	5,590	C	*	*
346	Metal forgings and stampings	904	*	E	15,972	1,023	*	1,013
347	Metal services, n.e.c.	*	*	*	2,189	B	*	*
349	Miscellaneous fabricated metal products	980	B	444	4,571	E	E	686
353	Construction and related machinery	4,265	*	*	6,205	135	*	322
354	Metalworking machinery	1,493	236	516	13,097	71	*	*
355	Special industry machinery	783	C	*	3,887	*	*	*
356	General industrial machinery	C	*	*	4,063	*	G	605
357	Office and computing machines	*	*	*	F	*	*	*
359	Miscellaneous machinery, except electrical	1,252	58	B	6,642	160	E	367
362	Electrical industrial apparatus	334	C	G	7,012	C	*	*
363	Household appliances	*	*	B	2,051	C	*	*
364	Electrical lighting and wiring equipment	250	B	C	4,658	*	*	*
369	Miscellaneous electrical equipment and supplies	B	*	F	4,286	B	*	B
371	Motor vehicles and equipment	891	*	F	21,138	*	G	984
372	Aircraft and parts	B	*	*	5,757	*	*	*
376	Guided missles, space vehicles, parts	*	*	*	G	*	*	*
382	Measuring and controlling devices	G	E	*	2,942	*	*	E
393	Musical instruments	F	*	*	62	*	*	C
399	Miscellaneous manufactures	246	*	*	1,939	557	*	E
---	Total manufacturing, CBP	27,395	6,202	13,506	234,512	8,426	7,958	13,905
---	Total private sector, CBP	61,282	14,690	27,727	689,748	23,483	13,983	27,636
---	Total manufacturing, BEA	25,507	6,797	13,916	237,128	8,035	7,661	13,465
---	Total private sector, BEA	65,792	18,644	35,277	742,764	28,584	17,420	35,221
---	Total all sectors, BEA	76,558	21,466	40,165	851,303	33,129	19,870	42,317

*Industry not present in the county.

Range of employment effect--B:20-99; C:100-249; E:250-499; F:500-999; G:1,000-2,499; H:2,500-4,999; J:10,000-24,999.

Source: U.S. Department of Commerce, Bureau of the Census, County Business Patterns (CBP), 1978, Washington, D.C., 1981.

interdicted counties, and that a large percentage[4] of the direct impacts could be mitigated by a "clean up" undertaken in the decontamination part of the physically affected area. Therefore, only a small percentage of the direct impacts should be expected to persist after the first three months following the accident.

Table 7.7 shows the effects of the accident on aggregated industry-specific employment, both in the physically affected area and in the physically unaffected area. Economic effects in the physically unaffected area could occur because of (1) decreased exports to (demand by) the physically affected area, (2) tourist avoidance, and (3) decreased imports from (supply by) the physically affected area. (These effects are on an annual basis for 1978; therefore, job lost in the decontamination area is counted as one-quarter of a job.) Major direct effects could amount to 5.3 percent of the total employment in the Perry economic area and would occur in durable goods manufacturing (which includes machinery), retail trade, and services. Indirect effects are considerably smaller. Tourist-related effects take place in services (where the direct effects on hotel and lodging places are the largest part) and retail trade (where the direct effects on eating and drinking establishments are the largest part).

As shown in table 7.8, several industries in the physically unaffected area are vulnerable to supply constraints. (The employment effects are on an annual basis.) Since the constraints were estimated after first permitting output to increase up to maximum desired capacity in the physically unaffected area, employment losses would occur in these industries if they were unable to import,

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4. For the interdicted and decontamination areas combined, the decontamination area represents 87 percent of BEA total employment.

Table 7.7.--Private-Sector Employment Losses (1978) Due to an SST1-SW, Perry Nuclear Reactor

(Thousands of annual jobs)

Industry	Total employment		Direct losses in the physically affected area	Indirect losses in the physically unaffected area due to		
	U.S.	Study area		Decreased exports	Tourist avoidance	Supply constraints*
Agriculture	3,417	142	9	0	0	
Mining	901	33	1	0	0	
Construction	5,387	297	15	0	0	Probably small
Nondurables manufacturing	8,377	509	27	0	2	Probably small
Durables manufacturing	12,519	1,337	72	0	0	Probably small
Transportation, communication, and utilities	5,159	304	14	0	0	
Wholesale trade	5,248	300	21	0	1	
Retail trade	16,198	1,045	58	0	11	
Finance, insurance, and real estate	5,190	279	14	0	0	
Services	20,630	1,173	57	0	13	
Total	**83,026**	**5,419**	**288**	**0**	**27**	

*For more details on the potential size of individual constraints, see table 7.8.

Table 7.8.--Selected Private-Sector Employment Supply Constraints and Vulnerabilities (1978) Due to an SST1-SW, Perry Nuclear Reactor

(Thousands of annual jobs)

Constraining industry in the physically affected area			Directly vulnerable industries in the physically unaffected area		
SIC code	Industry name	Number	SIC code	Industry name	Number
01,02	Agriculture	10	20	Food and kindred products	12
35	Nonelectrical machinery	6	33	Primary metals	4
			371	Motor vehicles	3
36	Electrical machinery	6	15-17	Contract construction	7
			35	Nonelectrical machinery	13
			371	Motor vehicles	3

from elsewhere in the United States, required inputs no longer avaliable from the physically affected area. Since increased imports from elsewhere in the United States could be forthcoming, rather than ascribing estimated employment losses to these industries, these industries are designated as "vulnerable" to the employment losses of the size shown in table 7.8. Some of the vulnerable employment might be expected not to represent lost employment. For example, to avoid the loss of 23,000 jobs in contract construction, nonelectrical machinery, and motor vehicles in the physically unaffected area, the output of 6,000 jobs in electrical machinery might be imported from outside the study area. However, several linkages of constraining industry with vulnerable industries are likely to result in lost employment. Contract construction could be expected to have difficulties in locating another source of electrical machinery (SIC 36), because the Perry economic area accounts for a significant amount of the U.S. output of electrical machinery, and it is doubtful if secondary sources could be found outside of the Perry area.

Table 7.9 shows employment (annual basis) losses when the two compensating effects have taken place. If output increased up to maximum desired capacity in the physically unaffected area, but households had not yet resumed their normal consumption, then job losses in nondurable manufacturing would be more than halved. However, losses in retail trade and services would decrease only slightly since these industries are affected primarily by household expenditures. If household expenditures attained their former level, total job losses would decrease considerably. Only agriculture and mining, which are assumed to be unable to expand capacity in the one-year impact interval adopted in this study, show the same job losses as in the initial case. However, it is important to recognize that the difference between the initial case and the

Table 7.9.--Private-Sector Employment Losses (1978) Due to an SST1-SW, Perry Nuclear Reactor

(Thousands of annual jobs)

Industry	Direct losses[1]	Partially compensated losses[2]	Fully compensated losses[3]
Agriculture	9	9	9
Mining	1	1	1
Construction	15	14	1
Nondurables manufacturing	27	15	12
Durables manufacturing	72	29	28
Transportation, communication, and utilities	14	10	3
Wholesale trade	21	18	2
Retail trade	58	56	2
Finance, insurance, and real estate	14	10	1
Services	57	50	5
Total	**288**	**212**	**64**

1. Direct losses in the physically affected area; see table 7.7.

2. Partially compensated losses would occur, if output increases up to the maximum desired capacity in the physically unaffected area, but households do not resume normal consumption.

3. Fully compensated losses would occur, if output increases up to maximum desired capacity in the physically unaffected area, and households resume normal consumption.

fully compensated case is itself a measure of the size of the adjustment that must occur in the physically unaffected area. Considerable time may be required for the physically unaffected area to assimulate all but 64,000 of the initial 288,000 annual jobs directly affected.

Chapter 8

FERMI NUCLEAR REACTOR

The industrial impact model used to estimate the private-sector effects of a hypothetical accident at the Fermi nuclear reactor indicates that the total employment loss in all industries directly affected by the accident could be 51,000 (less than one-half of 1 percent of the total employment in the economic area surrounding the Fermi reactor site). In addition to large direct effects in agriculture (primarily in dairy farm products, miscellaneous livestock, and food and feed grains), major impacts could occur in durable goods manufacturing (for example, the production of motor vehicles and equipment), retail trade, and services. Impacts associated with a decrease in tourist activity could be as high as 77,000 jobs, primarily in eating and drinking places, and in hotels and other lodging places. Finally, the model indicates that indirect industrial effects are relatively small, and that up to 20,000 annual jobs in the food and kindred products industry are vulnerable to the decreased availability of agricultural inputs.

Economic Profile

Population and earnings, 1969-78

On July 1, 1978, the population of the study area[1] was 30.6 million, up 3.0 percent since July 1, 1969 (table 8.1). The area's increase was little

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[1] The study area includes two BEA economic areas in Ohio: 069 Lima and 070 Toledo; three economic areas in Michigan: 072 Saginaw-Bay City, 073 Grand Rapids, and 074 Lansing-Kalamazoo; seven economic areas in Indiana: 075 South Bend, 076 Fort Wayne, 077 Kokomo-Marion, 078 Anderson-Muncie, 079 Indianapolis, 081 Terre Haute, and 082 Lafayette; five economic areas in Illinois: 083 Chicago, 084 Champaign-Urbana, 085 Springfield-Decatur, 087 Peoria, and 088 Rockford; and three economic areas in Wisconsin: 089 Milwaukee, 090 Madison, and 094 Appleton-Green Bay-Oshkosh. The remainder of the study area consists of three SMSA's in Ohio--Cleveland, Lorrain-Elyria, and Mansfield--and three counties in Ohio--Crawford, Erie, and Huron.

Table 8.1.--Population, Personal Income, Earnings, and Employment, 1969, 1978, and Projected 1985-2000

Fermi Study Area

	1969	1978	1985*	1990*	2000*
Population, July 1 (thousands)	29,706	30,600	31,719	32,711	34,087
		(millions of 1972 dollars)			
Total personal income (place of residence)	135,755	174,641	223,052	260,882	331,403
Earnings (place of work)1/	114,144	140,140	180,840	211,697	270,997
Farm	2,322	2,281	2,587	2,785	3,272
Nonfarm1/	111,822	137,859	178,253	208,912	267,725
Private1/	98,782	120,953	157,668	185,224	237,939
Agricultural services, forestry, fisheries, and other2/	221	296	382	440	546
Mining2/	378	541	778	917	1,126
Construction	7,501	7,596	9,908	11,596	14,921
Manufacturing	44,858	53,711	67,847	78,323	97,835
Nondurable goods	10,804	11,942	14,536	16,656	20,386
Durable goods	34,054	41,769	53,311	61,667	77,449
Transportation, communication, and utilities	7,316	9,452	12,221	14,376	18,503
Wholesale trade2/	6,948	8,966	11,445	13,113	16,322
Retail trade	11,569	12,813	16,294	18,814	23,695
Finance, insurance, and real estate	5,266	6,981	9,707	11,758	15,852
Services	14,725	20,597	29,086	35,887	49,139
Government	13,040	16,906	20,585	23,688	29,786
Federal civilian	2,292	2,651	3,225	3,673	4,585
Federal military	692	530	615	690	842
State and local	10,056	13,725	16,745	19,325	24,359
		(thousands of jobs)			
Total employment (place of work)1/	12,888	14,352	16,031	16,792	17,516
Farm	302	293	271	258	244
Nonfarm1/	12,586	14,059	15,760	16,534	17,272
Private1/	10,728	11,949	13,514	14,226	14,915
Agricultural services, forestry, fisheries, and other2/	34	48	54	57	59
Mining2/	33	35	42	43	42
Construction	618	650	747	779	816
Manufacturing	4,168	4,051	4,336	4,428	4,433
Nondurable goods	1,099	1,056	1,106	1,131	1,135
Durable goods	3,069	2,995	3,230	3,297	3,298
Transportation, communication, and utilities	670	683	733	754	768
Wholesale trade2/	626	752	846	880	910
Retail trade	1,957	2,314	2,643	2,795	2,946
Finance, insurance, and real estate	552	703	856	923	999
Services	2,070	2,713	3,257	3,567	3,942
Government	1,858	2,110	2,246	2,308	2,357
Federal civilian	237	214	220	223	225
Federal military	214	143	143	143	143
State and local	1,407	1,753	1,883	1,942	1,989

*Projected years are from OBERS Scenario II.

1. Excludes earnings or employment for Crawford County, Ohio for those industries indicated by footnote 2.

2. Excludes earnings or employment for this industry in Crawford County, Ohio. Information is omitted to avoid disclosure of individual firm data.

NOTE: The sum of the excluded earnings in Crawford County, in millions of 1972 dollars, are, 16, 25, 29, 32, and 39 respectively for each of the published years. For employment, the comparable numbers, in thousands, are, 2, 3, 3, 4, and 4.

more than one-third that for the Nation as a whole (table 8.2). In 1969, the study area's per capita income was $4,570, 10 percent more than nationally.[2] In 1978, it was $5,707, 9 percent more than nationally.

From 1969 to 1978, total earnings increased 22.8 percent in the area, compared with a 29.4-percent national increase. During the 9-year period, area earnings increased less than nationally in each industry except durable goods manufacturing, which increased 22.7 percent in the area and 20.7 percent nationally. In addition, farm income declined 1.8 percent in the area while increasing 12.6 percent nationally, and Federal military government income declined 23.4 percent in the area and 14.7 percent nationally. In 1978, area earnings totaled $140.1 billion, or 15.9 percent of the United States total.

In 1969, durable goods manufacturing registered the largest location quotient (LQ)--1.64--of all area industries, reflecting the area's export base in durable goods products (table 8.3).[3] In 1969, durable goods manufacturing accounted for 29.8 percent of the study area's total earnings (the LQ for nondurable goods manufacturing, which accounted for 9.5 percent of total earnings, was .90). Industries with above-average shares (relative to the Nation) were construction, with an LQ of 1.03 and accounting for 6.6 percent of total area earnings, and wholesale trade, with an LQ of 1.02 and accounting for 6.1 percent of total area earnings. Industries registering shares that were well below average (relative to the Nation) included Federal military (with an LQ of .27) and Federal civilian (.47). In contrast, State and local government, accounting for 8.8 percent of total area earnings, registered an LQ of .89.

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2. All per capita income and earnings are expressed in 1972 dollars.

3. An earnings (or employment) LQ is the percent of total area earnings (or employment) originating in an industry divided by the percent of national earnings (or employment) originating in the same industry.

Table 8.2.--Population, Personal Income, Earnings, and Employment, Percent Changes, Selected Years, 1969-2000

Fermi Study Area

	1969-78		1978-85*		1985-2000*	
	Percent change	Relative to U.S.	Percent change	Relative to U.S.	Percent change	Relative to U.S.
Population, July 1	3.01	.36	3.66	.56	7.47	.63
Total personal income (place of residence)	28.64	.78	27.72	.90	48.58	.86
Earnings (place of work)	22.77	.77	29.04	.92	49.85	.88
Farm	-1.77	-.14	13.42	1.54	26.48	1.09
Nonfarm	23.28	.78	29.30	.92	50.19	.88
Private	22.44	.75	30.35	.89	50.91	.86
Agricultural services, forestry, fisheries, and other	33.94	.62	29.05	.91	42.93	.80
Mining	43.12	.43	43.81	.90	44.73	.92
Construction	1.27	.06	30.44	.93	50.60	.88
Manufacturing	19.74	1.09	26.32	.89	44.20	.84
Nondurable goods	10.53	.78	21.72	.90	40.24	.84
Durable goods	22.66	1.09	27.63	.85	45.28	.82
Transportation, communication, and utilities	29.20	.73	29.30	.89	51.40	.86
Wholesale trade	29.04	.70	27.65	.89	42.61	.85
Retail trade	10.75	.52	27.17	.92	45.42	.86
Finance, insurance, and real estate	32.57	.83	39.05	.99	63.30	.97
Services	39.88	.90	41.21	.97	68.94	.92
Government	29.65	1.01	21.76	.99	44.70	.94
Federal civilian	15.66	.72	21.65	1.00	42.17	.97
Federal military	-23.41	1.59	16.04	.99	36.91	1.00
State and local	36.49	.85	22.00	.96	45.47	.90
Total employment (place of work)	11.36	.62	11.70	.85	9.26	.67
Farm	-2.98	.39	-7.51	.90	-9.96	.95
Nonfarm	11.70	.61	12.10	.85	9.59	.66
Private	11.38	.55	13.10	.82	10.37	.66
Agricultural services, forestry, fisheries, and other	41.18	.73	12.50	.85	9.26	.63
Mining	6.06	.15	20.00	.95	- - -	- - -
Construction	5.18	.21	14.92	.91	.24	.82
Manufacturing	-2.81	-1.59	7.04	.67	2.24	.23
Nondurable goods	-3.91	10.86	4.73	.71	2.62	.35
Durable goods	-2.41	-.74	7.85	.60	2.11	.19
Transportation, communication, and utilities	1.94	.17	7.32	.72	4.77	.47
Wholesale trade	20.13	.62	12.50	.79	7.56	.62
Retail trade	18.24	.65	14.22	.88	11.46	.68
Finance, insurance, and real estate	27.36	.80	21.76	.91	16.71	.82
Services	31.06	.94	20.05	.98	21.03	.89
Government	13.56	.97	6.45	.93	4.94	.63
Federal civilian	-9.70	15.65	2.80	.78	2.27	.57
Federal military	-33.18	1.17	- - -	- - -	- - -	- - -
State and local	24.59	.75	7.42	.82	5.63	.57

*Projected years are from OBERS Scenario II.

NOTE: Percent changes and relatives are calculated from rounded data.

Table 8.3.--Earnings and Employment, Percent Distributions, and Location Quotients, 1969, 1978, and Projected 1985-2000

Fermi Study Area

	1969		1978		1985*		1990*		2000*	
	Percent distribution	LQ	Percent distribution	LQ	Percent distribution	LQ	Percent distribution	LQ	Percent distribution	LQ
Earnings (place of work)	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00
Farm	2.03	.70	1.63	.65	1.43	.69	1.32	.70	1.21	.73
Nonfarm	97.97	1.01	9.37	1.01	98.57	1.01	98.68	1.01	98.79	1.00
Private	86.54	1.07	86.31	1.07	87.19	1.05	87.49	1.05	87.80	1.05
Agricultural services, forestry, fisheries, and other	.19	.54	.21	.51	.21	.50	.21	.51	.20	.49
Mining	.33	.33	.39	.25	.43	.24	.43	.24	.42	.25
Construction	6.57	1.03	5.42	.89	5.48	.90	5.48	.90	5.51	.90
Manufacturing	39.30	1.37	38.33	1.46	37.52	1.45	37.00	1.44	36.10	1.43
Nondurable goods	9.47	.90	8.52	.92	8.04	.92	7.87	.92	7.52	.92
Durable goods	29.83	1.64	29.81	1.75	29.48	1.72	29.13	1.70	28.58	1.68
Transportation, communication, and utilities	6.41	.91	6.74	.88	6.76	.88	6.79	.87	6.83	.87
Wholesale trade	6.09	1.02	6.40	.98	6.33	.97	6.19	.96	6.02	.96
Retail trade	10.14	.95	9.14	.91	9.01	.91	8.89	.91	8.74	.91
Finance, insurance, and real estate	4.61	.86	4.98	.86	5.37	.88	5.55	.89	5.85	.91
Services	12.90	.85	14.70	.87	16.08	.88	16.95	.89	18.13	.89
Government	11.42	.69	12.06	.73	11.38	.75	11.19	.75	10.99	.76
Federal civilian	2.01	.47	1.89	.47	1.78	.48	1.74	.49	1.69	.50
Federal military	.61	.27	.38	.25	.34	.26	.33	.26	.31	.27
State and local	8.81	.89	9.79	.89	9.26	.91	9.13	.91	8.99	.91
Total employment (place of work)	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00
Farm	2.34	.67	2.04	.75	1.69	.77	1.54	.78	1.39	.80
Nonfarm	97.66	1.01	97.96	1.01	98.31	1.01	98.46	1.00	98.61	1.00
Private	83.24	1.07	83.26	1.05	84.30	1.04	84.72	1.04	85.15	1.03
Agricultural services, forestry, fisheries, and other	.26	.53	.33	.51	.34	.52	.34	.52	.34	.52
Mining	.26	.35	.24	.27	.26	.27	.26	.28	.24	.28
Construction	4.80	.95	4.53	.85	4.66	.85	4.64	.86	4.66	.87
Manufacturing	32.34	1.35	28.23	1.37	27.05	1.35	26.37	1.33	25.31	1.31
Nondurable goods	8.53	.87	7.36	.89	6.90	.89	6.74	.89	6.48	.88
Durable goods	23.81	1.68	20.87	1.69	20.15	1.64	19.63	1.61	18.83	1.57
Transportation, communication, and utilities	5.20	.96	4.76	.93	4.57	.93	4.49	.92	4.38	.92
Wholesale trade	4.86	1.05	5.24	1.01	5.28	1.00	5.24	1.00	5.20	1.00
Retail trade	15.18	1.02	16.12	1.01	16.49	1.01	16.64	1.00	16.82	1.00
Finance, insurance, and real estate	4.28	.95	4.90	.96	5.34	.95	5.50	.96	5.70	.96
Services	16.06	.88	18.90	.93	20.32	.94	21.24	.95	22.51	.96
Government	14.42	.76	14.70	.82	14.01	.83	13.74	.84	13.46	.84
Federal civilian	1.84	.54	1.49	.52	1.37	.53	1.33	.53	1.28	.54
Federal military	1.66	.43	1.00	.43	.89	.44	.85	.44	.82	.46
State and local	10.92	.96	12.21	.96	11.75	.96	11.56	.96	11.36	.96

*Projected years are from OBERS Scenario II.

NOTE: Percent distributions calculated from rounded data.

Services, although accounting for 12.9 percent of the area's total earnings, registered an LQ of only .85. Other industries with shares only slightly below the national norm were finance-insurance-real estate (with an LQ of .86), retail trade (.95), and transportation-communication-utilities (.91); the three services industries together accounted for slightly over one-fifth of the study area's total earnings in 1969.

In 1978, the same situation generally prevailed, with several exceptions. Durable goods manufacturing earnings increased their LQ to 1.75, while maintaining the same percent share of total earnings as in 1969. Construction earnings registered a lower LQ in 1978--.89--and a smaller share of total earnings--5.4 percent--than in 1969. The wholesale trade LQ was also lower in 1978--.98--but its share of total earnings increased slightly to 6.4 percent. From 1969 to 1978, durables goods manufacturing earnings rose 22.7 percent, 1.1 times the U.S. rate, and wholesale trade earnings rose 29.0 percent, less than three-fourths the U.S. rate. Construction earnings, however, rose only 1.3 percent during the period, compared with a U.S. increase of 23.0 percent.

Projected population and earnings, 1978-2000

The population of the area is projected to increase to 31.7 million by 1985, and to 34.1 million by 2000. This represents a population increase of 3.7 percent from 1978 to 1985, slightly more than one-half the national rate, and an additional increase of 7.5 percent from 1985 to 2000, less than two-thirds the national rate.

In 1985, the study area's per capita income is projected to be $7,032, and in 2000, to be $9,722. These figures will be 10 and 8 percent, respectively, over comparable U.S. per capita incomes.

Area earnings are projected to reach $180.8 billion in 1985 and $271.0 billion in 2000. This represents an increase of 29.0 percent from 1978 to 1985, and an additional 50.0 percent from 1985 to 2000. These projected area increases will be 92 and 88 percent, respectively, of corresponding national increases.

Earnings in durable goods manufacturing are projected to yield slightly declining LQ's of 1.72 in 1985 and 1.68 in 2000. Construction is the only other industry in the area projected to have LQ's of over 1.00--1.45 in 1985 and 1.43 in 2000. Several additional industries are projected to maintain relatively high LQ's; i.e., .90 or more: nondurable goods manufacturing, wholesale trade, retail trade, and State and local government. Federal civilian and Federal military earnings are projected to maintain low LQ's. Earnings in all of these industries are projected to account for smaller percentages of total area earnings by 2000 of up to 1 percentage point with the exception of construction, where earnings will account for 5.5 percent of total area earnings, slightly more than in 1978. Earnings in only one industry, services, are projected to appreciably increase their share of total area earnings, from 14.7 percent in 1978 to 18.1 percent in 2000. At the same time, the services LQ will increase slightly, from .87 in 1978 to .89 in 2000.

Employment, 1969-78

In 1978, employment totaled 14.4 million, up 1.5 million since 1969, an increase of 11.4 percent. In relative terms, however, total employment in the area increased at less than two-thirds the national rate.

In 1978, the area's largest employer was the durable goods manufacturing industry (3.0 million, or 20.9 percent of the total), followed by services (18.9 percent), retail trade (16.1 percent), and State and local government (12.2

percent). Durable goods manufacturing and retail trade registered employment LQ's of 1.69 and 1.01, respectively, and services, an LQ of .93, and State and local government, an LQ of .96. Mining registered the lowest employment LQ in 1978, only .27, and Federal military, the next lowest LQ, .43.

In the 1969-78 period, employment in durable goods manufacturing declined 2.4 percent, compared with a 3.3-percent national increase. In fact, all area industries performed more poorly than their national counterparts during this period. Services employment increased 31.1 percent versus 33.1 percent nationally, retail trade employment increased 18.2 percent, only two-thirds the national rate of increase, and State and local government employment increased 24.6 percent, only three-fourths the national rate. Federal military registered the greatest absolute decline in employment, 33.2 percent (versus a decline of 28.5 percent nationally) and Federal civilian had the next greatest decline, 9.7 percent (versus a decline of 0.6 percent nationally).

Projected employment, 1978-2000

Total employment in the area is projected to increase to 16.0 million in 1985 (11.7 percent over 1978), and to 17.5 million in 2000 (9.3 percent over 1985). From 1978 to 1985, the area's employment rate of increase is projected to be 85 percent of the national rate of increase, compared with 62 percent of the national rate during the 1969-78 period; from 1985 to 2000, it is projected to stand at 67 percent of the national rate.

Durable goods manufacturing employment is projected to increase 7.9 percent from 1978 to 1985 (three-fifths the national rate) and from 1985 to 2000, to increase 2.1 percent (one-fifth the national rate). With the exception of mining and Federal military, both minor employers in the study area, the durable goods manufacturing industry is projected to register the smallest gain in employment in 1978-2000, in both percentage terms and relative to the Nation. In contrast, services employment is projected to register the largest increases: 20.1 and 21.0 percent, respectively, during the two projection periods, 98 and 89 percent, respectively, of national rates of increase. Services is the study area's only industry to project a larger employment increase in 1985-2000 than in 1978-85. Like durable goods manufacturing and services, all remaining industries are projected to have lower employment changes relative to the Nation in 1985-2000 than in 1978-85.

In future years, employment in durable goods manufacturing is projected to decrease its share of total area employment, to 20.9 percent in 1978 and 18.8 percent in 2000. Concurrently, the industry's employment LQ will decline gradually to 1.57 in 2000, still retaining the top-ranking employment LQ among all industries in the study area. Other industries projected to retain employment LQ's of 1.00 or so, are wholesale trade and retail trade. Services employment is projected to increase its share of total employment more than any other industry, to 18.9 percent in 1978 and 22.5 percent in 2000, and to increase its employment LQ to .93 in 1978 and .96 in 2000.

Impacts: SST1 Towards W

The industrial impact model was run for a reactor accident scenario (SST1) for a west (W) wind vector. Table 8.4 shows both the counties affected by the accident and the differing types of effects in these counties. For this hypothetical accident, table 8.5 shows the large directly affected agricultural and manufacturing industries; output data are estimated by RIMS II. (Nonagricultural output in the decontamination counties is lost for 3 months, so that if the decontamination counties accounted for 4 percent of U.S. output in a particular industry, this would appear as 1 percent in the table.) Total

Table 8.4.--Production Loss, by County, Fermi Nuclear Reactor, SST1-W (22.5° arc)

Type of production loss	Counties	Length of production loss	Extent of tourist avoidance
Physical contamination: All industries	Physically affected: Interdicted (21 miles) Monroe, MI (host county)	More than 1 year, all industries including agricultural production	100% for more than 1 year
All industries, except agriculture	Decontamination (94 miles) Lenawee, MI Hillsdale, MI Branch, MI	Three months loss in nonagricultural output; one year loss in all crop output, except no loss in greenhouse, nursery, and forestry output; three months loss in dairy output; and six months loss in livestock and poultry output	100% for 3 months, then 75% for 9 months
Agriculture, except dairy milk	Crop-interdicted (271 miles) All of the above, and St. Joseph, MI Cass, MI Van Buren, MI Kalamazoo, MI Calhoun, MI Elkhart, IN Lagrange, IN	No loss in nonagricultural output; one year loss in agricultural output, except no loss in greenhouse, nursery, and forestry output; no loss in livestock and poultry output; and two months loss in dairy output	45% for 1 year; except in the interdicted and contaminated areas as noted above
Dairy milk only	Milk-interdicted (298 miles) All of the above, and Berrien, MI Lake, IN Porter, IN Laporte, IN St. Joseph, IN Boone, IL Mc Henry, IL Lake, IL De Kalb, IL Kane, IL Du Page, IL Cook, IL La Salle, IL Kendall, IL Grundy, IL Will, IL Walworth, WI Kenosha, WI	No loss of output in any industrial sector, except two months loss in dairy output	45% for 1 year; except in the interdicted and contaminated areas as noted above
Indirect economic effects:	Physically unaffected: BEA Economic Areas* 69, 70, 72-79, 81-85, 87-90, and 94, plus the Cleveland, Lorrain-Elyria, and Mansfield SMSA's, plus Crawford, Erie, and Huron counties in Ohio, less above counties	First year only, based on RIMS II	10% for 1 year

*For component counties, see BEA Economic Areas (Revised 1977), BEA, U.S. Department of Commerce, Washington, D.C.

employment and selected industry-specific employment in each county of the interdicted and decontamination area are shown in table 8.6; actual levels (rather than one-quarter shares of annual totals for the decontamination area) are for 1978. Tables 8.5 and 8.6 indicate that major industrial effects would occur in transportation equipment (SIC 37) and fabricated metal products, except machinery and transportation equipment (SIC 34). Table 8.6 indicates that a significant part of the total direct industrial effects would take place in the interdicted county, but that an even larger part[4] of the direct impacts could be mitigated by a "clean up" undertaken in the decontamination part of the physically affected area. Only one-third of the direct nonagricultural impacts should be expected to persist after the first three months following the accident.

Table 8.7 shows the effects of the accident on aggregated industry-specific employment, both in the physically affected area and in the physically unaffected area. Economic effects in the physically unaffected area could occur because of (1) decreased exports to (demand by) the physically affected area, (2) tourist avoidance, and (3) decreased imports from (supply by) the physically affected area. (These effects are on an annual basis for 1978; therefore, a job lost in the decontamination area is counted as one-quarter of a job.) Major direct effects would occur in agriculture, durable goods manufacturing, retail trade, and services. Even greater effects would occur in tourist-related industries such as retail trade (where the direct effects on eating and drinking establishments are the largest part) and services (where the direct effects on hotel and lodging places are the largest part).

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[4] For the interdicted and decontamination areas combined, the interdicted area represents only 32 percent of BEA total employment.

Table 8.5.--Large Direct Effects in Agriculture and Manufacturing Due to an SST1-W, Fermi Nuclear Reactor

Industry name	SIC code	Percent range of U.S. output
Food grains	part of 01	1-5
Feed grains	part of 01	1-5
Dairy farm products	part of 02	1-5
Miscellaneous livestock	part of 02	1-5
Condensed and evaporated milk	2032	1-5 C
Flour and other grain mill products	2041	1-5 C
Wood kitchen cabinets	2434	1-5 C
Wood pallets and skids	2448	1-5 I
Upholstered household furniture	2512	1-5 I
Paper board mills	263	1-5 I
Die-cut paper and board	2645	1-5 I
Adhesives and sealants	2891	1-5 C
Synthetic rubber	2822	1-5 C
Cement, hydraulic	324	1-5 I
Pottery, products, n.e.c.	3269	1-5 I
Abrasive products	3291	1-5 C
Electrometallurgical products	3313	1-5 C
Steel pipe and tubes	3317	1-5 I/C
Brass, bronze, and copper castings	3362	1-5 C
Heating equipment, except electric	3433	1-5 I
Metal doors, sash, and trim	3442	1-5 C
Miscellaneous fabricated wire products	3495-6	1-5 C
Refrigeration and heating equipment	3585	1-5 C
Motor vehicle parts and accessories	3714	1-5 I

I indicates that effects occur primarily in the interdicted area.

C indicates that effects occur primarily in the decontamination area.

I/C indicates that large effects occur in both areas.

Table 8.6.--Large Direct Effects on Manufacturing Employment (1978) Due to an SST1-W, by County, Fermi Nuclear Reactor

SIC code	Industry name	Number of employees affected for more than one year	Number of employees affected for three months		
		Monroe, MI	Branch, MI	Hillsdale, MI	Lenawee, MI
202	Dairy products	B	*	*	B
204	Grain mill products	*	*	C	*
243	Millwork, plywood, and structural members	*	B	C	F
244	Wood containers	*	*	*	60
251	Household furniture	F	*	*	*
263	Paperboard mills	C	*	*	*
264	Miscellaneous converted paper products	*	*	*	C
282	Plastics materials and synthetics	E	*	*	E
289	Miscellaneous chemical products	*	*	*	B
324	Cement, hydraulic	E	*	*	*
326	Pottery and related products	B	*	*	*
329	Miscellaneous nonmetallic mineral products	*	215	*	C
331	Blast furnace and basic steel products	B	C	*	C
336	Nonferrous foundries	*	*	*	C
343	Plumbing and heating, except electric	E	*	C	*
344	Fabricated structural metal products	*	F	*	134
349	Miscellaneous fabricated metal products	*	276	E	F
358	Refrigeration and service machinery	*	*	F	G
371	Motor vehicles and equipment	H	F	G	F
---	Total manufacturing, CBP	9,592	4,646	4,690	11,915
---	Total private sector, CBP	23,735	9,282	8,460	23,983
---	Total manufacturing, BEA	7,831	5,277	5,010	12,234
---	Total private, BEA	27,361	14,050	13,398	30,667
---	Total all sectors, BEA	33,198	18,813	15,625	36,030

*Industry not present in the county.

Range of employment effect--B:20-99; C:100-249; E:250-499; F:500-999; G:1,000-2,499;H:2,500-4,999.

Source: U.S. Department of Commerce, Bureau of the Census, County Business Patterns (CBP), 1978, Washington, D.C., 1981.

Table 8.7.--Private-Sector Employment Losses (1978) Due to an SST1-W, Fermi Nuclear Reactor

(Thousands of annual jobs)

Industry	Total employment		Direct losses in the physically affected area	Indirect losses in the physically unaffected area due to		
	U.S.	Study area		Decreased exports	Tourist avoidance	Supply constraints
Agriculture	3,417	341	19	0	0	
Mining	901	35	0	0	0	
Construction	5,387	650	2	0	0	
Nondurables manufacturing	8,377	1,056	3	1	3	20*
Durables manufacturing	12,519	2,995	8	1	0	
Transportation, communication, and utilities	5,159	683	3	1	1	
Wholesale trade	5,248	752	1	1	2	
Retail trade	16,198	2,314	7	0	39	
Finance, insurance, and real estate	5,190	703	1	0	1	
Services	20,630	2,713	7	0	31	
Total	**83,026**	**12,242**	**51**	**4**	**77**	

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*Up to 20,000 annual jobs in the food and kindred products industry (a part of nondurables manufacturing) in the study area are vulnerable to the decreased availability of agricultural inputs.

Only one industry in the physically unaffected area, nondurable goods manufacturing (of food and kindred products), is vulnerable to a supply constraint. (The employment effect is on an annual basis.) The constraint is estimated after first permitting output to increase up to maximum desired capacity in the physically unaffected area, and the employment loss would occur in this industry if it was impossible to import, from elsewhere in the United States, required inputs no longer available from the physically affected area.

Table 8.8 shows employment (annual basis) losses when two compensating effects have taken place. If output increased up to maximum desired capacity in the physically unaffected area, but households had not yet resumed their normal consumption, then job losses in nondurables manufacturing would be halved. However, losses in retail trade and services would decrease only slightly since these industries are affected primarily by household expenditures. If household expenditures attained their former level, total job losses would decrease considerably. Only agriculture, which is assumed to be unable to expand capacity in the one-year impact interval adopted in this monograph, shows the same job loss as in the initial case. However, it is important to recognize that the difference between the initial case and the fully compensated case is itself a measure of the size of the adjustment that must occur in the physically unaffected area. Some time may be required for the physically unaffected area to assimulate all but 21,000 of the initial 51,000 annual jobs directly affected.

Table 8.8.--Private-Sector Employment Losses (1978) Due to an SST1-W, Fermi Nuclear Reactor

(Thousands of annual jobs)

Industry	Direct losses[1]	Partially compensated losses[2]	Fully compensated losses[3]
Agriculture	19	19	19
Mining	0	0	0
Construction	2	1	0
Nondurables manufacturing	3	0	0
Durables manufacturing	8	1	0
Transportation, communication, and utilities	3	2	0
Wholesale trade	1	1	1
Retail trade	7	6	0
Finance, insurance, and real estate	1	1	0
Services	7	6	1
Total	**51**	**37**	**21**

1. Direct losses in the physically affected area; see column 3, table 8.7.

2. Partially compensated losses would occur, if output increases up to the maximum desired capacity in the physically unaffected area, but households do not resume normal consumption.

3. Fully compensated losses would occur, if output increases up to maximum desired capacity in the physically unaffected area, and households resume normal consumption.

Chapter 9

CONCLUSION

An industrial impact model of disasters (based on RIMS II) was developed and used to estimate private-sector industry-specific output and employment impacts of a possible SST1 nuclear reactor accident (a "worst-case" scenario) occurring at three sites. Several concluding observations on the results obtained from three case studies serve to highlight crucial characteristics of the industrial impact model, and the NRC-supplied assumptions.

First, for all three studies, the size of the direct nonagricultural losses in the physically affected area depends on the amount of economic activity occurring in the interdicted and decontamination areas. For this reason, nonagricultural losses in the Fermi and St. Lucie studies are less than those in the Perry study. Furthermore, the industry-specific distribution of direct losses depends on the industrial structure of the physically affected areas. For instance, durables manufacturing direct losses represent more than 15 percent of the total direct losses in the Fermi and Perry studies, but less than 3 percent in the St. Lucie study.

Second, the persistence of the impacts beyond the one-year time period adopted in the case studies depends on the extent to which the total directly affected output originated in the interdicted area. For example, when compared to the St. Lucie study, smaller percentages of the total industrial impacts originated in the interdicted areas in the Perry and Fermi studies. In these latter studies, a large portion of the direct employment losses were due to effects in the decontamination area, which, according to the NRC assumptions, would become usable again within three months after an accident.

Third, vulnerabilities in terms of supply constraints can be large, especially those associated with agriculture. In the case studies, the unavailability of agricultural inputs is identified as potentially affecting between 12,000 and 30,000 jobs in food processing in the physically unaffected areas. A large part of the estimated vulnerabilities in food processing would be likely to occur, since the supply of agricultural commodities is nearly fixed for the one-year time period adopted in this study. Other indirect effects (in terms of decreased exports to the affected area) in the physically unaffected area are small relative to the direct losses in the physically affected area. In the case studies (each of which involves several interdicted or decontamination counties), the industrial impact model estimates large local interindustry relationships within the physically affected area itself.

Fourth, indirect effects due to tourist avoidance can be large; in the Fermi study, these effects (77,000 jobs) are larger than the direct losses (51,000 jobs). This occurs, in part, because Chicago, a site for major business conventions, is included in Fermi's milk-interdicted area, where tourist avoidance is assumed to be 45 percent for one year. The estimates of the total impacts of tourist avoidance should be viewed as sensitive to the NRC-supplied percentages that indicate the extent of tourist avoidance in each type of physically affected area.

Fifth, the part of the direct loss in manufacturing output that can be compensated for in the unaffected area varies among the case studies and depends on the industry-specific amount of excess capacity in the unaffected area. In the Fermi study, there is sufficient excess capacity in the study area, so that 90 percent of the employment loss in manufacturing can be made up; in the Perry study, the loss is 44 percent. In general, the larger (in terms of output) the total study area relative to the physically affected area, the greater would be the mitigation of the direct loss.

Finally, even if output could increase in the physically unaffected area, there might be insufficient household demand for that output if employees who previously worked in the physically affected area either were not compensated for their lost income, or remained in "evacuation centers," rather that resuming their normal level of consumption expenditures. The potential impacts of households not maintaining their normal expenditures is large, especially in the local service-type industries. For example, in the Perry study, the effect of households not resuming normal expenditures represents all but 64,000 of the 288,000 jobs directly affected by the hypothetical SST1 accident. On the other hand, it is important to recognize that even if households were able to resume normal consumption expenditures, considerable time may be required for the physically unaffected area to assimulate all but 64,000 of 288,000 jobs directly affected.

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Appendix A

UNITED STATES TABLES

Table A.1.--Population, Personal Income, Earnings, and Employment, 1969, 1978, and Projected 1985-2000, United States

	1969	1978	1985*	1990*	2000*
Population, July 1 (thousands)	201,298	218,051	232,346	242,979	259,845
		(millions of 1972 dollars)			
Total personal income (place of residence)	834,161	1,139,744	1,491,758	1,772,172	2,336,905
Earnings (place of work)	679,459	879,168	1,155,351	1,371,067	1,810,100
Farm	19,647	22,125	24,059	25,751	29,921
Nonfarm	659,812	857,042	1,131,292	1,345,316	1,780,179
Private	547,994	712,445	954,975	1,141,500	1,519,806
Agricultural services, forestry, fisheries, and other	2,351	3,637	4,798	5,648	7,371
Mining	6,812	13,701	20,397	24,208	30,285
Construction	43,305	53,248	70,653	83,774	111,246
Manufacturing	195,226	230,514	298,825	351,398	455,749
Nondurable goods	71,421	81,065	100,588	117,058	148,660
Durable goods	123,805	149,450	198,237	234,340	307,089
Transportation, communication, and utilities	47,899	67,166	89,245	106,867	142,582
Wholesale trade	40,698	57,615	75,610	88,102	113,518
Retail trade	72,679	87,792	113,788	133,345	173,671
Finance, insurance, and real estate	36,477	50,805	70,801	85,911	116,804
Services	102,547	147,968	210,858	262,247	368,580
Government	111,817	144,598	176,317	203,816	260,372
Federal civilian	28,876	35,123	42,742	48,926	61,411
Federal military	15,515	13,231	15,371	17,248	21,039
State and local	67,427	96,243	118,204	137,642	177,922
		(thousands of jobs)			
Total employment (place of work)	85,416	101,118	114,965	121,986	130,943
Farm	2,987	2,757	2,527	2,411	2,262
Nonfarm	82,429	98,361	112,438	119,575	128,681
Private	66,546	80,267	93,086	99,556	107,816
Agricultural services, forestry, fisheries, and other	422	660	756	803	867
Mining	638	901	1,091	1,133	1,108
Construction	4,320	5,387	6,275	6,589	6,979
Manufacturing	20,532	20,896	23,097	24,165	25,326
Nondurable goods	8,407	8,377	8,935	9,266	9,595
Durable goods	12,124	12,519	14,162	14,899	15,731
Transportation, communication, and utilities	4,643	5,159	5,681	5,938	6,254
Wholesale trade	3,961	5,248	6,079	6,410	6,822
Retail trade	12,662	16,198	18,820	20,195	21,980
Finance, insurance, and real estate	3,865	5,190	6,436	7,013	7,753
Services	15,503	20,630	24,851	27,310	30,727
Government	15,883	18,094	19,352	20,019	20,865
Federal civilian	2,899	2,881	2,985	3,044	3,103
Federal military	3,287	2,351	2,342	2,342	2,342
State and local	9,697	12,862	14,025	14,633	15,420

*Projected years are from OBERS Scenario II.

NOTE: Details may not add to totals because of rounding.

Table A.2.--Population, Personal Income, Earnings, and Employment, Percent Changes and Percent Distributions, Selected Years, 1969-2000, United States

	1969-78	1978-85*	1985-2000*	1969	1978	1985*	1990*	2000*
	Percent change	Percent change	Percent change	Percent distribution	Percent distribution	Percent distribution	Percent distribution	Percent distribution
Population, July 1	8.32	6.56	11.84	- - -	- - -	- - -	- - -	- - -
Total personal income (place of residence)	36.63	30.89	56.65	- - -	- - -	- - -	- - -	- - -
Earnings (place of work)	29.39	31.41	56.67	100.00	100.00	100.00	100.00	100.00
Farm	12.61	8.74	24.37	2.89	2.52	2.08	1.88	1.65
Nonfarm	29.89	32.00	57.36	97.11	97.48	97.92	98.12	98.35
Private	30.01	34.04	59.15	80.65	81.04	82.66	83.26	83.96
Agricultural services, forestry, fisheries, and other	54.66	31.94	53.63	.35	.41	.42	.41	.41
Mining	101.12	48.87	48.48	1.00	1.56	1.77	1.77	1.67
Construction	22.96	32.69	57.45	6.37	6.06	6.12	6.11	6.15
Manufacturing	18.08	29.63	52.51	28.73	26.22	25.86	25.63	25.18
Nondurable goods	13.50	24.08	47.79	10.51	9.22	8.71	8.54	8.21
Durable goods	20.71	32.64	54.91	18.22	17.00	17.16	17.09	16.97
Transportation, communication, and utilities	40.22	32.87	59.76	7.05	7.64	7.72	7.79	7.88
Wholesale trade	41.57	31.23	50.14	5.99	6.55	6.54	6.43	6.27
Retail trade	20.79	29.61	52.63	10.70	9.99	9.85	9.73	9.59
Finance, insurance, and real estate	39.28	39.36	64.98	5.37	5.78	6.13	6.27	6.45
Services	44.29	42.50	74.80	15.09	16.83	18.25	19.13	20.36
Government	29.32	21.94	47.67	16.46	16.45	15.26	14.87	14.38
Federal civilian	21.64	21.69	43.68	4.25	4.00	3.70	3.57	3.39
Federal military	-14.72	16.17	36.87	2.28	1.50	1.33	1.26	1.16
State and local	42.74	22.82	50.52	9.92	10.95	10.23	10.04	9.83
Total employment (place of work)	18.38	13.69	13.90	100.00	100.00	100.00	100.00	100.00
Farm	-7.70	-8.34	-10.49	3.50	2.73	2.20	1.98	1.73
Nonfarm	19.33	14.31	14.45	96.50	97.27	97.80	98.02	98.27
Private	20.62	15.97	15.82	77.91	79.38	80.97	81.61	82.34
Agricultural services, forestry, fisheries, and other	56.29	14.62	14.68	.49	.65	.66	.66	.66
Mining	41.07	21.16	1.56	.75	.89	.95	.93	.85
Construction	24.69	16.48	11.22	5.06	5.33	5.46	5.40	5.33
Manufacturing	1.77	10.53	9.65	24.04	20.66	20.09	19.81	19.34
Nondurable goods	-.36	6.66	7.39	9.84	8.28	7.77	7.60	7.33
Durable goods	3.25	13.13	11.08	14.19	12.38	12.32	12.21	12.01
Transportation, communication, and utilities	11.11	10.13	10.09	5.44	5.10	4.94	4.87	4.78
Wholesale trade	32.50	15.83	12.22	4.64	5.19	5.29	5.25	5.21
Retail trade	27.93	16.19	16.79	14.82	16.02	16.37	16.56	16.79
Finance, insurance, and real estate	34.27	24.02	20.46	4.52	5.13	5.60	5.75	5.92
Services	33.07	20.46	23.64	18.15	20.40	21.62	22.39	23.47
Government	13.92	6.95	7.82	18.59	17.89	16.83	16.41	15.93
Federal civilian	-.62	3.61	3.95	3.39	2.85	2.60	2.50	2.37
Federal military	-28.48	-.38	.00	3.85	2.33	2.04	1.92	1.79
State and local	32.64	9.04	9.95	11.35	12.72	12.20	12.00	11.78

*Projected years are from OBERS Scenario II.

NOTE: Percent changes and percent distributions calculated from rounded data.

BEA ECONOMIC AREAS

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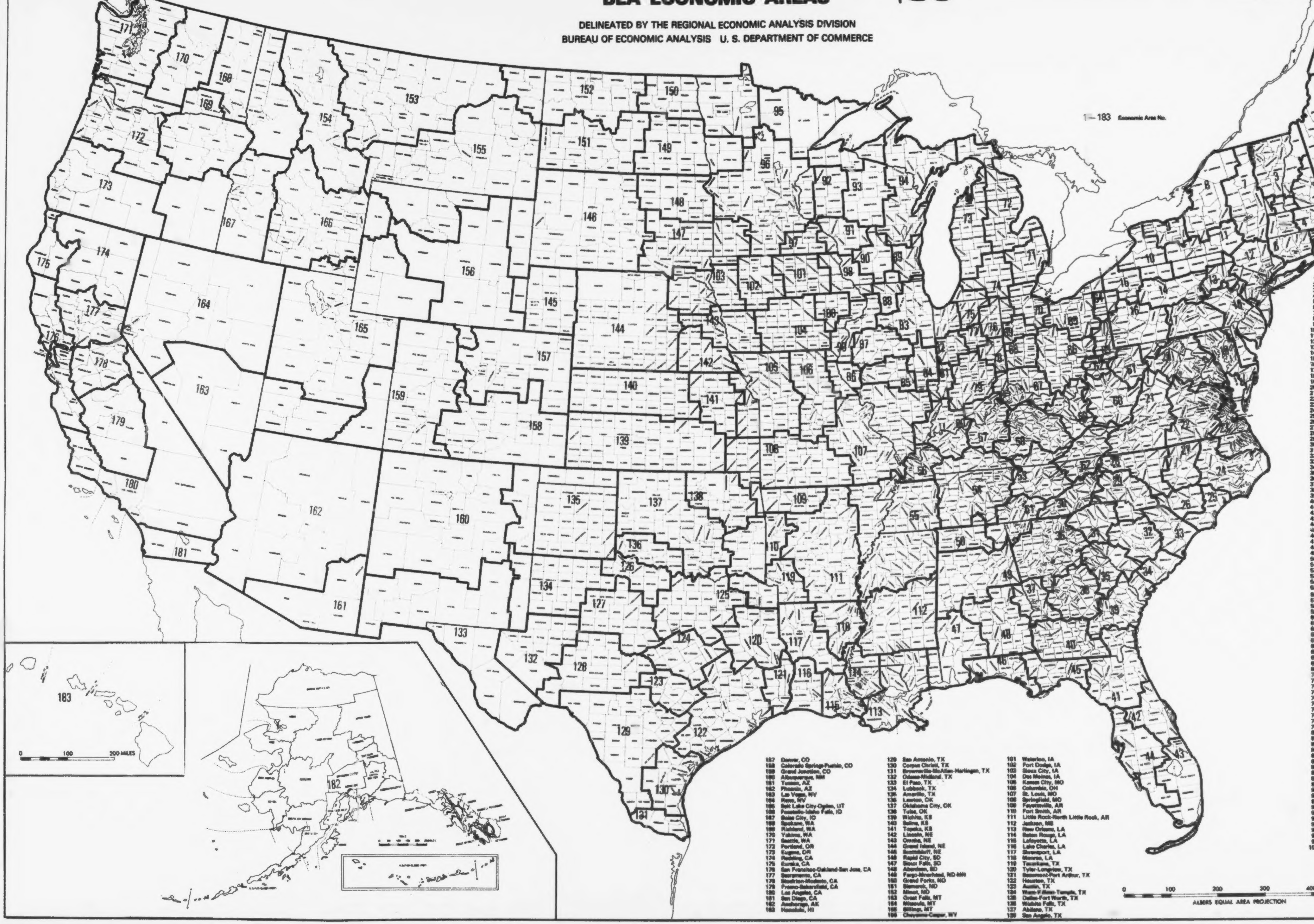
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16. ABSTRACT *(200 words or less)*

This NUREG describes an industrial impact model that can be used to estimate the regional industry-specific impacts of disasters, both natural and manmade. Special attention is given to the impacts of possible nuclear reactor accidents. The report also presents three applications of the model. The impacts estimated in the case studies are based on (1) general information and reactor-specific data, supplied by the U.S. Nuclear Regulatory Commission (NRC); (2) regional economic models derived from the Regional Input-Output Modeling System (RIMS II) developed at the Bureau of Economic Analysis (BEA); and (3) additional methodology developed especially for taking into account the unique characteristics of a nuclear reactor accident with respect to regional industrial activity.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

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